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## THE COTTON FIBRE.*


BY THOMAS PRAY, JR.


[*A Lecture delivered before the* FRANKLIN INSTITUTE, *Friday, December 2, 1887.*]

The Speaker was introduced by Dr. WM. H. WAHL, Secretary of the INSTITUTE, and spoke substantially as follows:

MR. CHAIRMAN, MEMBERS OF THE FRANKLIN INSTITUTE, LADIES AND GENTLEMEN:

The cotton fibre is one of the subjects with which we are most intimately acquainted, and fifty of the sixty million people of the United States are in closer contact with the

* This lecture was copiously illustrated with the aid of the projecting lantern. A few of the pictures shown have been here reproduced (see *Frontispiece*), because of their value as exhibiting the contrast in physical characteristics. These illustrations are copyrighted and used by permission from *The Cotton Fibre and Cotton Spinner*.—(COM. PUB.)

cotton fibre than with anything else, and three-quarters of the other ten millions buy cotton with their wool, as you are probably aware; and yet there are very few indeed who know very much about the fibre, and not one in a thousand of the cotton manufacturers of the country who can tell you very much about the fibre except that they grind out "so many" bales a week, and make so many bales a week of cotton sheetings, shirtings or something else out of a fibre of which they know very little indeed. I believe, in my profession as an engineer, in counting, weighing and measuring everything, and making all my deductions so clear that they are of the "knock-down" order, for, in that way, I can compel attention and make my statements based only upon fact, thus compelling also agreement with my showing, and it is with that purpose in view that I propose to show you to-night, instead of asking you to take my observations without the proof positive being also introduced. All the pictures that I may show you this evening are my own work in the cotton field, as are the photo-micrographs, which you will have thrown on the screen, so that you can see exactly as I have seen, all the physical features of the cotton fibre as far as I can see them, with the exception that from several hundred slides I have been, on account of time, compelled to select a few, some thirty in number, instead of several hundreds. I am also going to tell you at the start that my "hobby," as some spinners are pleased to call it, has been ridden to some purpose, and that some few cotton spinners are making use of the microscope in their cotton mills now, and are really beginning to understand that there is a better way of buying cotton, or mixing it after it is bought, than the old way. Just imagine a man going into a darkened room to buy silks, and depending upon "feeling" with his fingers; he might tell that the fabric was silk, but what could he tell about the color or texture? So, in buying cotton, what could a man tell about a cotton fibre which is all the way from $\frac{1}{900}$ of an inch in diameter for the coarsest Upland, to $\frac{1}{1200}$ for the best New Orleans, or Gulf, and $\frac{1}{2000}$ for the best Sea Island cotton, which is raised in the United States? And yet from 1,500,000 bales

upwards are worked in the United States in this blind way of guessing, or supposing, and turning out such goods as it happened to produce.

The subject is interesting from more points than one and I will now proceed (with the assistance of my friend at the lantern) to show you exactly what I am going to talk about. The first is the locomotive upon which I arrived at the scene of my operations in the cotton field. You will see that the trade-mark of the Baldwin Locomotive Works, Philadelphia, is upon the front of the engine. There is nothing peculiar except it is a wood-burner, and the scenery is peculiarly Southern. The next is a scene clearly Southern, and represents such a crowd as I found one Sunday afternoon in an out-of-the-way country town, where the people were very much surprised at our appearance. In the next, you will have a view of the planter's house, which was my home during all my tramps for four years during the cotton planting and picking seasons; you will see in the strong sunlight just what I saw when looking through the lens of my camera; the house you will see is set up three and a half or four feet from the ground, on account of moisture, and for sanitary reasons; these houses are usually only one-story high, with a broad stoop, and are very pleasant, I can assure you. In our next, we have one of the most beautiful scenes in nature; although our magazines and other literature have a great deal to say about the grandest sight in nature, but, after travelling pretty thoroughly in various countries of the world, I have never seen anything to my own eye more beautiful than a cotton field, just as you see it now on the screen. This is an Upland field, and the cotton is fully open, not quite ready for the picking. Here we have not the "ship of the desert," which, if any of you have ever travelled in the Holy Land, you will remember, but you have the ship of the "cotton field and his navigator," the negro and the mule; while in the distance you will see the "quarters" where the negroes live, and of which you will soon have a very much nearer and plainer view. In this one you have a first-rate view of the bottom land cotton field, perfectly white with bloom, in which you will see the

planter and two boys, and when I tell you that Major Jones is five feet ten inches high, you will be able to judge that the cotton is pretty nearly three feet high, as it comes fully up to his hips. In the next, you have a nearer view of the cotton pickers in working costume. You will notice that each one has grasped a cotton boll in the right hand, while with the left they pick out the fibre from the shell and leave the shell on the stalks of the plant, but put the fibre or "lint" in the "pocket," which you will see each one is furnished with, hanging to the side; this is a woman and her two sons, just as I found them in the field. Here we have the cotton picker again, a nearer view, very much; you can see that very little clothing is worn, and very little outfit is necessary. In this view we have the quarters as they stand in the fields all over the thirteen or fourteen cotton-growing States. The building is, as you will see, of the common hard pine, about 10 x 12 or 12 x 16 feet on the ground, only a single story high, with a mud chimney, sides only battened and the roof covered with rough boards and shingles; in these places the families of negroes live, anywhere from two to a dozen, while very many of the negroes have little houses of their own, which are better somewhat. You will see the mother and her three boys just as I found them after the forenoon's work, each with a pouch or "pocket," while the mule and boy are probably sent from the planter to tell the pickers where to work in the afternoon. In the next, you will see how the pickers get their pay for the work done. Here are the three sons of the planter, with the colored boy and the big cotton baskets. You will see, also, the heads of the horses. The cotton is taken from the pockets or pouches and put into the baskets, and you will see the scales, and the smallest boy has a book in which the weight of each basket is entered, and then the cotton is put into the wagon, and then, in too many cases, the cotton is put into piles on the ground, where it waits for ginning and for the rain; here very much of the cotton is spoiled, and very much, indeed, is materially injured by rain and dampness, etc.; but on the best regulated plantations it is housed until ready for going to the steam gin.

Here we have the cotton in another stage, or, as the negroes usually speak of it, "gwine to town;" you will have no trouble in this picture in telling that the colored people have taken in old uncle and auntie, besides the driver, and the journey to town will be one of the features of their next week's conversation.

This brings me to the "ginnery," where most of the cotton which is carefully raised and kept all right is ultimately spoiled, as far as the spinner goes. The competition in the ginning of cotton has been fierce. Steam gins have been built all over the South, and the cotton is practically ground up, mutilated or anything that you choose to say, except that it is properly ginned. But here you will have one of the few old-time cotton ginneries and presses that are standing. When I say old-time, it is with reference to before-the-war times. The gin-house you can see under the house proper, where the mules are attached to the wooden frame which carries a cast-iron segment upon it, into which a gear-shaft plays, upon the end of which is a pulley which drives the gin, which is put up in the second story, where the cotton is put after picking. The right-hand end of the house is what is called the lint-room, into which the cotton is sent by the action of the gin, and from this lint-room the negroes take the cotton and put it into the press, which is under the double roof, which you see farther at the right. The long, angular timbers which you see, are the levers by which a screw is worked, and you can, perhaps, imagine what the work was on rainy days or when the crop had been early picked. Many and happy have been the days that I have spent in listening to the melodies which were the universal accompaniment of this stage of the cotton crop, but those days have now gone. The march of improvement has displaced them with the steam gin, located in town, where the cotton can be sent off to the mill in an hour, or by the first train after the bale is ready.

Our next is a Southern town; this is one of very many that I have visited and there is very little difference indeed between them. You will see the usual crowd of loafing populace under the broad piazza; you can see the locks of

cotton lying in the street, see the load of cotton bales on the wagon and the three people who are gathered near it, discussing the price probably, one being the planter, another the merchant, who has probably a mortgage on the crop of which the bales are a part, and the other, as you will see from his black face, is the driver. It does not require any great effort to see the words "Bar Room," but whether they are in greater number than they are in Philadelphia, I cannot say. The next is a cotton plant, which, as you will see, broke down under its load in the field, and I was obliged to tie it up so as to photograph it. This was large Upland cotton, and had 227 bolls upon it; if a whole acre could have been raised as good as this, it would have yielded over four bales, of 450 pounds each, for each acre. The next is a boll of cotton, perfect and beautiful. The next is an arrangement of six bolls of different cotton, all arranged upon the same field, so that you can begin the study of the physical difference in cotton. In these six bolls you will find all the difference that you can find in an hour's study of 500 faces, if you will stand on Chestnut or Market Street here at any hour of the day. The upper central is a poorly developed boll of Upland, grown upon poor soil. The lower middle boll was grown upon better Upland soil. The lower right-hand is good Upland, upon well-fertilized soil, and the upper right-hand is Upland cotton grown upon bottom land; while the lower left-hand is Mississippi cotton, the best in the world, excepting only that which is called Sea Island. Now as we proceed you will find the same physical characteristics in a fibre of cotton that you can so plainly see in these six cotton bolls, and the differences in the fibres when you have studied them for a little while will, I am sure, convince you, each and every one, that cotton is capable of being worked differently for different purposes, and with a very great difference in results, if only we can make the selection possible and practical. As you have seen the Upland cotton in the field, before I commence the fibres I will show you the bottom land or low-land cotton as it grows. In this slide, as you will see, the cotton plants are taller, stronger and very much thicker in their growth;

in fact, it is almost impossible when the cotton is fully grown to go through a field of this cotton; and the fibre is like the plant, longer, stronger and more of it on a boll.

We will now begin on the fibres. In this you have a photo-micrograph of a few fibres of cotton taken from some of the best Pernambuco cotton. It will be noticed that it is rather flat and that the fibres are more of the nature of narrow tape. The edges are not thickened and, as you will see in the slides that follow, there is very little or no spirality in the fibres. The oil deposits are few indeed and not very marked. The next slide is from Upland cotton, which is not very well developed (see *Fig. A, frontispiece*). It will be readily seen that the cotton is not strong and robust in appearance, but that the fibres are weak in their outline, not very well thickened on the edges, but that the spirality is more noticeable than in the slide last shown. There are some traces of oil deposits, but it is of the same not clearly-developed type—it will be found by the spinner that the cotton will have the same actual effect in the machinery, and the resultant goods will be weak and uneven, just as the cotton appears on the screen now. No one in this audience will have the least trouble in noticing all the different features between the cotton fibre now on the screen and the one which immediately preceded it. This is Upland Georgia cotton, raised in 1881 or 1882, from seed carefully selected from the first picking and the most perfect bolls; the cotton fibre, as you will notice, is beautifully developed, clear in its outline, well-formed, full of oil deposits and very good spirality (see *Fig. B, frontispiece*). The average crop of this cotton was one and one-quarter bales per acre, where in the old times before the war one-half a bale per acre "was a pretty good yield." This cotton was raised by Major James F. Jones, a native Georgian, living in Troup County. He commenced farming upon the small farm idea, after he found himself getting poorer and poorer after the war, running under the old idea of as many mules as he could work; he commenced using fertilizers and planting a few acres and taking care of them, instead of planting a great many acres and

letting them go in the shiftless, not-taken-care-of way, that was the usual practice. When the Major made his appearance at the Atlanta Exhibition in 1880, and in his modest way made the statement of what he was doing, his statements were doubted, in fact; it was even intimated as probable that "the Major lied." I had read the articles in the *Atlanta Constitution*, and found the Major out upon my arrival there, and afterward had the pleasure of introducing the Major to Mr. Edward Atkinson and his party of New England cotton-spinners upon their arrival there. Mr. Jones has done very much indeed to reform the slack, shiftless ways of farming, and I am glad to say has been successful as far as dollars and cents go. This cotton has been spread all over the South, and the seed sold at $2 a bushel, when the common cotton-seed was a drug at twelve and one-half to sixteen cents a bushel. This particular sample of cotton that I gathered in the Major's cotton field with my own hands remains almost the best developed, strongest and most valuable of any cotton that I have in my collection of thousands of samples, from all sorts of soil and countries, with the exception of Sea Island, and the fine high-grade cottons which you will presently see from the Delta of the Mississippi, where the finest cottons in the world are raised, without any exception whatever. Major Jones' cotton, unlike very many of the "hybrid cottons" and "seedling cottons," which have appeared on the market and soon disappeared, has never changed, but has grown in favor, and when kept pure, has made a material change in the yield in different soils, and is perfectly available as a "cropping" cotton, as the Southern people say.

The finest cotton raised anywhere in the cotton fields of the world, is the Mississippi Delta cotton; beautiful in its structure; perfect in its development; full of oil deposits, with a spirality of nearly 400 per inch, making very strong yarn, capable of coloring all the delicate shades, like pink, light colors, and bleaching in the most perfect manner (see *Fig. C, frontispiece*). If you will compare this cotton in its appearance only, with any other that has been shown, you will have no more trouble in reaching your own conclusion,

than if you were looking at a beautiful oil-painting from the hands of one of the masters or at a six-penny daub. And the physical characteristics are as clearly shown and follow in their working as the appearance of the cotton on the screen with that which has been or which will be shown. This particular cotton has a diameter of about $\frac{1}{1600}$ of an inch and is simply the "perfection of cotton." This slide shows the greatest possible contrast; it is one of the many good-for-nothing hybrids and seedlings and is not now grown to any extent. It requires very little more than to say it is worthless for anything, except wherever weight is required; it is lacking in spirality, oil deposit and development, and is easily disposed of. But who can tell this from the usual examination that is made by pulling a few fibres through the fingers? That is the question which makes or breaks a mill and its owner, and is for you to consider as you follow the subject along.

This is a micro-photograph, as indeed all the slides shown are, but it is a very much higher power than the others, and is shown so you can see the cell walls and deposits clearly. In the case of the "bubble," apparently you see the cell flat, and in the next fibre above it, you will see the same oily deposit; but you are, in the second case, looking at the edge of the cell or multitude of cells. There are many very foolish ideas about cotton, and one is that it has a unicellular structure, or with a single cell. Some three years ago, a little argument was had in Boston, and it has been told that a person with an itching for standing as a microscopist made the assertion that the oil deposits were simply air bubbles, and some idea was put forth of drawing them out with a glass-rod heated with a Bunsen burner. Ignorant people sometimes make themselves ridiculous, but seldom in such a way as this (and it was published as a fact), and, perhaps, some of you Philadelphia spinners can secure the services of the ignorant person to drive the air-bubbles out of the bales of cotton you are working.

In this slide you are again looking at a Mississippi cotton, a special hybrid, raised upon the best soil and highly fertilized, by Colonel Ozier, near Corinth (see *Fig. D*,

*frontispiece*). This is almost as perfect as best Sea Island cotton, and is very little removed from it, except in its length; this particular cotton, not the finest, is nearly $\frac{1}{1600}$ of an inch in diameter, has from 400 to 440 spirals per inch, very well developed, indeed, full of oil deposit, and if you will look at the edge of the fibre, about in the middle of the field, it has the appearance of the side of a chain, so that you can readily see the edges of the links. This is one of the most beautiful cottons I have ever seen from any country, and Colonel Ozier has made a specialty for some years of raising it. This is the kind of cotton that is worth many millions. It is not a question of selling, but how much can I get? To my mind, there are very few subjects in the vegetable kingdom more beautiful than this particular cotton fibre.

Here we have another specimen in the "seedling" line of cotton. This was introduced, and from its very showing and the full and general appearance, it "took" among the buyers. There are middlemen in the North who bought it largely for two years. They do not buy it now, and it would be regarded as a breach of courtesy to ask them anything about seedling cotton. It is fairly well developed, but very irregular, indeed, lacking in spirality, having but a limited oil deposit, uneven in size, and it works by filling the mill with "flyings," or small particles of very short fibres, covering the machinery completely up, and makes less pounds of goods for each hundred pounds of cotton than almost any other cotton you can buy.

Almost all the photo-micrographs which have been shown you have been "projection," as it more nearly resembles the actual appearance under the lens of the microscope in a practical way. The slide now upon the screen is for definition and is by an immersion lens; in this view you can see the wrinkled appearance of the fibres as plainly as you can see the veins on the back of your hand; if you will take pains to study them for a moment, you will readily observe that they have no particular direction, nor, indeed, any spiral tendency or follow any line, but are really at all sorts of angles to the length of the fibre; as the fibre matures,

the watery portion of the matter contained in the fibre is evaporated by the sun after the shell of the boll breaks open and the oil-wax is hardened in this process and becomes visible; and the more oil or wax in the cotton the stronger the cotton is and the less liable it is to electrical disturbances in the cold, dry weather, or to "varying in numbers," of which we hear so much in the "dog days" or wet weather. If you will study this particular slide, you can see the analogy between the various slides already shown and this one in particular. Dyers and bleachers of fine cotton have their share of trouble in the working of cotton, and find spots which will not take color at all, or unevenly, etc. In this slide you have quite a number of cotton fibres which have been mordanted, or prepared for coloring. There is no trouble whatever in discovering a great difference between the fibres, for their formation is clearly apparent and the peculiar markings which you observe show that in some parts of the fibre the mordant has taken hold and in others there is very little preparation for the coloring process which is to follow. Some of the fibres, you will notice, have taken up the solution in one part of the fibre and others in another; some of them show the edge and others the central portion ready for coloring; and it is not a matter of patience or pains by the dyer, but it is a matter beyond his reach, viz: the physical peculiarities of the cotton fibre which will not take the mordant, and we have often in our dye works or print works some pieces which cannot be either printed or colored anything else than black, and frequently the higher colors have to be "gone over" with the black on account of spots in them, which cannot be remedied by any known process of the art at the present time. It may be proper right here to observe that the microscopic examination of cotton has quite as much to do with the dyeing, printing, bleaching, etc., of cotton as with the work in the spinning-mill, and a vast amount of money is spent every year by the dyers, bleachers, printers, etc., that might be saved if a little common sense were exercised in the buying of cotton for the special purposes for which the goods are destined. Some very curious results have

come under my own observation during the past ten years in this respect, where each party has made absolute claims upon the other in cases for damage; and when observed carefully, it has been found that neither party could have avoided the result with the "cotton which was used," and yet, as a general thing, cotton-spinners, dyers, bleachers, printers, etc., ridicule the microscope as allied to the cotton mill!

In the following out-of-the-question explanations of the structure of the cotton fibre, which no person on the earth to-day knows positively in its completeness, some experiments have been made in dissolving cotton in various chemical solutions. The slide now upon the screen shows one of the most important. In this, you will clearly see that the outline of the fibre is plainly shown, so that there is an exact difference in the condition of the fibre in its present state or as to what it was in its completeness; it is a somewhat curious fact that the fibre dissolves very rapidly at first and more slowly as the inner layers are exposed to the action of the chemicals. The oil cells are the very last to disappear, partially because they are inside, but they are a great deal longer than all the rest of the fibre in dissolving; some thirty to thirty-six hours are required for complete dissolution in the strength of solvent used, and the slide shown was taken at about twelve hours from the mounting. It will be noticed that the fibres which are best developed are still plainest in their outlines, while those which show incompleteness are almost entirely destroyed. That there is a close analogy between the serviceableness of the cotton fibre in its completest development in the field, as to future usefulness, there is in my own mind not a particle of doubt. This is only a single slide, regarding the fibre chemically in this direction, but in connection with the one just shown, it seems to me all that is required in order to base an opinion upon.

We have heard a great deal about poor ginning. Cotton manufacturers complain about poor ginning, and if you will examine with a little care for a moment what is clearly seen on this slide, you can imagine it multipled by millions in

every bale of cotton and not go far wrong. The end fibres are mutilated as though torn by some mechanical means, and you will see several of them in the same field. The fibres, as you will see, are torn for some considerable length, and are shown with the short pieces pretty well in focus. Philadelphia being the city of the mechanic, it may be well to say right here that there is no field of speculative work that promises any more or richer return than the building of a good cotton-gin, one which will take the cotton off from the seed gently but clean; one that can be managed by the least possible mechanical talent, and such a machine will readily return to its inventor a million dollars quicker than in any one business that I know of. It may be well to remark, however, that the parties who take it up must be patient, faithful and capable of fighting. For Whitney died poor and discouraged, because he was robbed of his rights by the great American machinists, who stole his invention but laughed at his efforts to obtain something for the inventing. Since that time two very important inventions have been stolen, respectively one by an American and the other by an English house of machinists. There are cotton-gins put upon the market to-day which are entirely unworthy of the name of gin; they simply tear cotton all to pieces, and the spinner buys and pays for what is found all over the mill and machinery, and which never gets any farther than the sweepings, and goes into the "waste." At the time of the Atlanta Exhibition, in 1880, Mr. Edward Atkinson brought out the fact that I was making this investigation, at the same time that he told the people there that the harvesting of the crop of cotton was growing worse and worse. The first statement I can forgive him, though it has caused me any amount of trouble; the second was the truth, and if he had stated the whole truth he could have put it a great deal stronger. Since the time, when he made the statement, there have been a dozen or more different cotton-gins covered by patents which are somewhat changed to put on the market, which simply make the cotton worse instead of better. The sample shown you is not an extravagant one. It can be found in any bale of cotton any day of the week and in any

mill wherever cotton is worked into yarn, cloth or other goods. The cotton growers, factors, merchants, planters, middlemen and all the rest, if there be any, want a cotton-gin. Whether they will get any more for good than poor cotton is a very discouraging problem. I do not believe to-day that the New England cotton-spinners would pay a cent a bale for clean cotton or for better ginned cotton. If they can buy dirt or trash for a little less money they will buy it, or if they can buy it through some favored broker, it does not matter so much what the cotton is as what the price is. In this line some funny experiences have been mine within the twenty odd years I have been in active cotton-spinning; one in particular, where a treasurer "bought cotton" with the end of his cane. I have seen him go into a broker's office and punch some samples lying on the floor with the end of his cane and buy this or that lot, never feeling of the cotton, only asking, "What country is it?" "What price?" etc. It is perhaps superfluous to add that he "did not believe in the microscope," and yet this man did no worse than many of his fellow-treasurers to-day.

We have followed the cotton fibre through only a few of hundreds of slides, and now I will show you the sections of the cotton fibre from one end to the other of the fibre, or from the seed end to the outer end, and by a minute's looking over the field, you will have no difficulty in seeing all the different shapes of the fibre, in which you can find very many different forms. Here you have the end farthest from the seed, and here you will have a section from about the middle of the fibre; here you have a letter "U," and here another form; in some places it would seem almost as if there were only a single cell, while here you will have a section which plainly shows hundreds of cells, and in a similar direction. A whole evening might be spent upon this single slide, or, perhaps, with this and two or three others, with instruction, and, as a rule, the more we look at the fibre the more interested we become.

We will now look at a well-known muslin, which any lady here would buy at once on the reputation in the market. This photograph is from one of the best known family

muslins in the United States. You will observe that several threads are shown, and I wish to call your attention to the utter lack of "parallelism" in the threads. As a member of the New England Cotton Manufacturers' Association, in Boston, of which I have been a member nearly or quite twenty years, I have heard often long arguments about the parallelism of cotton fibres, etc. There is no more approximation to "parallelism" in the manufacture of cotton fibre than there is in the telephone or telegraph wires of Philadelphia, anywhere in the city, wherever they are, over buildings, on poles or across roofs. And here you can see it, if you will only follow out the fibres in the warp or filling. Please notice, also, all the difference in the size of the different threads, and these are among the actually best products of the loom and spindle in this country. Here we have another view of a piece from well-known mills, in which you will see even greater differences than in the slide which immediately preceded it. You will avoid any tendency to mistake as to warp or filling, observing that the vertical threads are one and the horizontal threads are the other, so that if our spinners present should take exception, it cannot be maintained, because both warp and filling are shown. The "parallelism" of the fibres can be readily seen, whatever there is of it. Here we will take leave of the cotton fibre, with a view of the cotton bales on a railroad depot platform in Georgia. The walk, up which you are looking towards the platform where the bales stand, is the connection with the "steam ginnery," one of the many which are now scattered through the South. Competition in the ginning of cotton has brought about changes which are perfectly ruinous to the cotton-spinner. In 1880, the price was $2 a bale for ginning 450 pounds, putting on jute bagging and the ropes or iron hoops, and the cotton was badly ginned then. More gins were put up, and the price gradually worked down to $1.25 per bale, and even lower than that in some cases, and the cotton was ginned with a vengeance, you may be sure. "Quantity" is the cry, and you never hear "quality." You say, how many bales will a gin do in a day, and if the makers say six, the owner

answers, make it do ten. And the spinner gets the benefit, if there is any to get. This subject will be sometime, in some ginnery, taken up, and radical improvements will be introduced, and perhaps there may be some improved methods of ginning cotton, in which the quality of the cotton fibre will be somewhat of an object. Cotton is now planted by guess, harvested by guess, ginned by the same, without regard to quality, and bought and sold by guess, and I may be allowed, perhaps, to guess that is the reason why some cotton mills do not pay dividends, although the large stockholders keep agents, and in some cases treasurers, in position, at $6,000 to $10,000 a year, buying by guess, making by guess, and declaring dividends whenever the officers' salaries are paid, and there is any money with which to do it. In other cases, agents and treasurers are paid $15,000 a year and the mills make money, keep up their machinery and plant in the best condition, and could, perhaps, do a great deal better if only they had some better way of buying or mixing cotton than by the feeling of an object which is $\frac{1}{1200}$ of an inch in diameter. Suppose a watchmaker should undertake the picking out of a pinion, where the bearings were $\frac{1}{200}$ of an inch different in size, with his fingers; how do you suppose the watch would run, if he happened to pick out one in which the size of the pinion was $\frac{1}{1200}$ of an inch too large? And yet cotton-spinners are doing worse than that every day of the week and every week of the year. I do not make these assertions from theoretical, but from practical connection with the cotton manufacture. My grandfather, my father and myself have been in it ever since 1796, and I may say now, I am probably mixing more cotton to-day for different mills than any other man in the United States; but there is very little hope indeed of any radical change in the methods of the present ginnery. The subject is away ahead of the average manufacturer, because the average manufacturer to-day is not a practical man, but the man who buys cotton knows very little about it, except as it is graded or shipped from such a port or such a place. The cotton interest is one of the largest in this country, as you all know. It is not my

purpose to criticise either the methods or the men who control them, but it is my purpose to present you only facts, which, in my vocation as an engineer, I have been many years learning, to count, measure and weigh facts, and present only facts, not theories. This investigation is from ten to twenty years ahead of the times. Men to-day are too much inclined to hire people for the least dollars, unless they are looking for a president or treasurer, and as the average man can never learn to use a microscope carefully or detect differences in cotton fibre, the microscope is not at a premium in the mind of the average middleman. Yet the fact remains. We are throwing away time and money; our mills are not earning what they might or ought. The cotton-planter is willing to raise better cotton, but the spinner is not ready or willing to pay for it. The cheapest stuff that can be bought for a certain price is what they are all looking for. Trouble among the help is continuous. Poor dividends regular in the most of cases. And where is the trouble? You have seen some of the outlines of the subject, which is great in its outreaching; you can judge for yourselves, and I believe any audience, whether of cotton-spinners, mechanics or otherwise, is intelligent enough to judge of the facts when presented. Very much more might be said, but I have only a few moments before my train leaves, and I must thank you for your courteous attention and kindness. I can truly say that I have enjoyed looking at the slides on the screen this evening, for I have had the best lantern service this evening of any illustrated lecture of the past twelve months.

# THE ARMY OF KUKUANALAND.

BY OTHO ERNEST MICHAELIS, Ph.D.,
United States Army.

[*A lecture delivered before the* FRANKLIN INSTITUTE, *March 11, 1887.*]

The Lecturer was introduced by the Secretary of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

I have had many misgivings whether or not the subject of to-night would yield material worth your hearing. That it will not prove unmitigatedly stupid, I hope—relying upon the apparently uniform interest that all good citizens take in military matters, either in vivid narrations of actual experience, or in open discussions of present or future policy. I suppose the majority of my hearers have read Rider Haggard's "King Solomon's Mines," and will recall Allen Quatermain's clear and simple story of the journey to Kukuanaland. You may recollect that in the introduction, Quatermain, recounting the many things upon which he might have dilated, mentions the "most interesting subject of the magnificent system of military organization in force in that country." Ignosi was, you remember, placed, by the aid of Quatermain and his friends, upon the throne, which his bloodthirsty Uncle Twala had usurped. After his thirty years' wanderings among civilized nations, with his quickness of perception, his retentive memory, and his facile adaptability, you may be sure he did nothing to lessen the military ardor and prestige of his people; on the contrary, he taught them all that he believed admirable, the matured results of long experience, observation and reflection. Upon these results, relating both to technical military details and to the broad questions of the relations between the people and the army, I propose to dwell this evening. Kukuanaland has no seaboard, and consequently Ignosi's genius avails us little in assisting to a solution of what is to

us the question of the hour—but it had neighbors to be feared.

You remember that Infadoos told Quatermain, soon after his entrance into the land, "When Twala, the King, calls up his regiments their plumes cover the plains as far as the eye of man can reach." "And if the land is walled in with mountains, who is there for the regiments to fight with?" "Nay, my lord, the country is open there," and again he pointed toward the north; "and now and again warriors sweep down upon us in clouds from a land we know not, and we slay them."

At the battle of Loo, Quatermain had a good opportunity of observing the conduct of the soldiers, of whom he says, and this will give you some idea of the character of the material upon which Ignosi worked, "Never before had I seen such an absolute devotion to the idea of duty, and such a complete indifference to its bitter fruits." In this instance they were "foredoomed to die."

Indeed, in that day, before Ignosi reigned, Quatermain tells us that, "In Kukuanaland, as among the Germans, every able-bodied man is a soldier, so that the whole force of the nation is available for its wars, offensive and defensive."

It is not necessary to give in detail the conversations carried on with the Kukuanian officials, it will suffice to report the conclusions in our own language, and I propose to present to this evening's audience only the more salient features of their military system, such as strike me as possessing general interest.

Considering its extent and population, the standing army of Kukuanaland is very small, but as its strength was fixed by the experienced Ignosi, we must assume that it was large enough for the needs of the country.

Kukuanaland is a land of workers—one person in every three of the whole population has a special trade or occupation; one in every seven is a farmer or stock raiser; one in every 800, a lawyer; one in every 770, a clergyman; one in every 600, a doctor; one in about every 200 is a teacher, and one in every 2,000, a soldier.

"Soldiering" is consequently, in Kukuanaland, a select profession. The term of enlistment is short, three years, the pay is excellent, increasing with length of service; the chances of promotion fair. In case of death in service a liberal pension is provided for dependent survivors. After eighteen years the soldier may retire on half pay; after twenty-four years, on three-quarter pay, and after thirty years, or in case of disability, on full pay.

After one enlistment, honorably terminated, the soldier has the first right to present himself for examination as a candidate for any vacancy occurring in the civil service of the government, for which he has presumable qualification. Soldiers are prohibited from marrying, a wise provision as will be seen, consistent with Ignosi's prominent motive, the maintenance of a natural military spirit among the people, an economical one, as it tends to keep the retired list small; for the natural desire of man for family relations induces many young soldiers to decline re-enlisting after having served one or more terms. One hundred officers are appointed every year, who must all be taken from the army, in compliance with rules and regulations which will presently be mentioned. The age of original enlistment is between seventeen and twenty-two years, excepting for graduates of special schools, who may be twenty-five; all soldiers between these ages are eligible for detail as cadets at the Government Military College, and the selection is entirely dependent upon their own aptitude and application, as determined by annual examination.

As a result, every vacancy in the army is eagerly sought for; the candidates for enlistment being so numerous that the government has been compelled to establish the most rigorous limiting rules.

The privilege of filling a certain number of annual vacancies has been granted to the advanced schools and colleges in the various provinces of the country, whence candidates are accepted on competitive examination. Many bright ambitious young men enlist, not only to gratify inborn military instincts, not only with the hope of promotion, but also to qualify themselves as candidates for civil

positions. Ignosi's wise policy has already borne fruit, for experience has shown that the young man who has the ability, both mental and physical, to serve with credit at least three years in the army, as a rule is a successful aspirant for the civil appointment.

As about one man in every hundred in Kukuanaland is a government employé, it is readily seen that gradually a large available, well-trained military reserve is forming without the slightest additional expense, for all officials must serve in the local reserve, of the formation of which I will say a word in passing.

The country is divided into departments, whose extent is mainly determined by geographical considerations. Each of these departments has its own organized reserve, in which service for three years is compulsory upon all men over twenty-one years of age, not otherwise exempted, and with which, as already stated, all government civil officials must, in time of peace, serve. The reserve is armed, equipped, clothed, and while in practice-encampment, fed and paid by the State. Army officers, line and staff, are detailed, in the various departments, to higher reserve positions, to insure uniformity of drill and methods.

The army is apparently numerously officered, about one officer for every ten men, but when the nature and scope of their duties are considered, the number is not too large.

There is only one way in Kukuanaland to a commission —by enlistment. As a rule the line appointments are made from those soldiers who have successfully passed through the course at the Government Military College, but not infrequently some bright non-commissioned officer will compete successfully for an appointment with the graduates of the school.

The general staff of his army has been a subject of much thought and study with Ignosi. It appears rather large for the mere wants of the standing army, but the King constituted it to meet the requirements of the nation even in case of a great war. Having made wise provision for the constant existence of a strong and available military element among his people, he yet felt that the special and

technical duties, so vitally important for the successful prosecution of war, could satisfactorily be performed only by men professionally competent. Hence the *personnel* of his grand staff was large enough to furnish representatives, in case of war, to all the principal subdivisions of the army, and for the charge of all its main supply and manufacturing depots. While thus able to deal with the affairs of an active army of 1,000,000 of men, its functions, in time of peace, were so directly connected with their welfare, that the people were well content both with the number and rank of the general staff officers.

As with all other branches of the service, these officers are appointed from the ranks after competitive examinations.

To obtain officers for the scientific and technical staff corps, Ignosi has availed himself of the studious and industrial characteristics of his people. Scientific and technological schools are found everywhere in his dominions and their graduates or advanced students, after enlistment and special *military* training at the Government Military College, are examined competitively for positions in the branches of the staff. When vacancies occur, examining boards are appointed in every military department of the country, and those who pass these boards are ordered to Loo, the capital, where a final examination determines the successful candidate.

The *élite* corps in the Kukuanian army is the inspector general's. An assistant inspector is appointed yearly from the captains of the army. The candidates, selected by the primary boards, are finally examined at Loo by a board consisting of the commanding general of the army and the chiefs of the grand staff. As a result, all the captains are ever studying to reach this goal, and the inspectors are consequently the brightest men in the army.

A peculiarity that characterizes the administration of military justice in Kukuanaland is worthy of mention.

There are no courts-martial, such as are familiar to us, except for cowardice, desertion and other capital offenses committed in the presence of the enemy, and for spies

caught red-handed. Judges properly assigned preside at all military trials, and officers constitute the jury, which renders a verdict, following the civil law, by a majority vote. The statutes fix the punishment.

Officers may retire after twenty years total service on half pay; after thirty years, on three-quarter pay; after forty years, they may, and after forty-five years, or in case of disability, they must, retire on full pay. As in the case of enlisted men, liberal pensions are given to dependent survivors. Officers are not permitted to marry before they have been ten years in service. Here again Ignosi has shown his far-reaching wisdom. For most active, exposed service, he has always at command a large body of eager, enthusiastic young men, untrammelled by immediate family ties. The retired list is kept within limits by the numerous resignations of those desiring "to take unto themselves wives," and who, as a rule, at once become applicants for civil appointments, and thus, in most instances, become important factors in the potential government reserve.

Of course my limits this evening are too narrow to permit my entering into a full and detailed account of the manner in which the Kukuanian army is armed, equipped, clothed and fed. This must be reserved for some future occasion. Still, I believe, that a recital of some of the deviations from accustomed ways, well known to you all, together with a brief *résumé* of Ignosi's reasons, be they good or bad, for such deviations, may not prove too great a strain upon your patience and good nature. In his wanderings Ignosi had become fully convinced of the truth of the nineteenth century canon of taste, that the useful must be the beautiful, that the fit, in its simplest form, is most pleasing, and he felt that the sooner the military taste of his countrymen were educated to appreciate the justice of this standard, the sooner they would become imbued with a more exact military spirit, reflexively producing an abler military service. He had seen in older countries famous horse-guard sentinels and their congeners still entrancing the eyes of servant-maids and footmen, he had seen the bright colors and glittering trappings of holiday soldiers

evoke the plaudits, yet want the respect, of crowded streets, and he had seen thousands of earnest men fighting for a principle, as freemen should, without crimson and gold. It was his ambition then to make the Kukuanian soldier a respected working member of a busy community, a man who need not blush because his tools, his clothes, his life were the useful concomitants, the proper exponent of his profession.

As Ignosi had no desire to make the military a class apart, but, on the contrary, to have it considered an essential and appreciated portion of the body-politic, he has been more impressed with the self-voiced personal wants of soldiers, in countries where they were patriotic citizens, endowed with all their rights, duties and feelings, than with the enforced methods of those other countries who maintained great armies for dynastic reasons, where soldiers were considered merely as "food for powder." Ignosi had become convinced that the ideal soldier would work hard, march long, fight well, starve, thirst and go naked, but would not embarrass himself with what he considers unnecessary burdens. He acknowledged that the soldier-citizen would not be a pack mule.

In this respect the soldier's feeling is simply an unconscious evolution of the *Zeitgeist*. Steam, electricity, air, the locomotive, the telegraph and telephone, and the balloon are mighty activities, not changing, but widely extending the underlying principle of warfare. A battle is an amplified prize-fight. When our modern gladiator stands in the arena, his antagonist establishes himself just beyond arm's length. This idea determines battle formations. The opponents array themselves just beyond the natural range of their weapons. Hence, since the first battle between Hercules and Antæus, the formation distance between combatants has increased directly with the reach of their arms. A line of battle may be likened to a Briareus, his many arms cover all the ground in front, and to the right and left of him, and hence follows not only space between, but also extension of the lines. So to-day, electricity and aëronautics afford the master mind, the commander-in-chief, a practical

*coup d'œil*, almost illimitable in extent as compared with the *terrain* of former days. Steam gives him the ability to place men and material rapidly where they are most needed. Ignosi recognized this modern condition of warfare, instinctively felt and acted upon by patriotic soldiers, and arrived at the inevitable conclusion, that, all else being granted, *mobility*, power to accomplish long, arduous, *rapid* marching, was the great *desideratum* in the wars of the future. Campaigns would be short and decisive, each having a distinct objective, and supplies in bulk for repair and recuperation, for renewal or continuance of operations, would have to be massed at suitable points, near in time, independently of the operating column. Hence his soldiers carried only their arms and ammunition, a haversack with a capacity of four days' rations, a tin cup able to stand the fire, a combined tin plate and frying-pan, forming a meat can (a Yankee notion), a fork, knife and spoon, a canteen for water, and a hunting-knife.

A soldier thus "outfitted" is before you on the screen. The hunting-knife, of a special design, originating with Lieut. Rodman, of the United States army, is worth dwelling upon for a moment. The shaft is built up of leather washers on the tang, and the blade has the cross-section shown, heavier towards the back, so that it may be handily used for hacking. In combination with the blade it can be utilized in emergency in throwing up effective temporary intrenchments. Carrying burdens is always a disagreeable necessity, and hence everything should be done to make it least irksome. You see here that the chest is left almost unrestricted, and a zinc shoulder-pad has been attached to the haversack and canteen straps to overcome any possible discomfort resulting from their "stringing." Ignosi deemed the fairly accurate judgment of distances as the most important element in military firing. It is a quality that few men can acquire intuitively. He accordingly supplied every individual in his army, officers and soldiers, with telemeters, instruments for determining the distance of an enemy. No complicated mathematical apparatus is practicable, the instrument must be simple in manipulation, and

give instantaneous correct results. He has adopted this simple little device, the invention of Colonel P. Le Boulengé, a distinguished Belgian officer, which gives the distance by noting the time elapsing between the flash and the report of the enemy's fire, and automatically translates this time into yards, as the air-velocity of sound is known. It makes allowance for changes in this velocity with varying temperature, and includes a correction for an average personal equation. The officers carry this little instrument in their pockets, and the men in the buts of their guns. It is here on the screen, where you can also see depicted the method of using the musket telemeter. One additional important use is worth mentioning. By observing the explosion of a shell, its range is determined. The error of the instrument is within the dangerous space of modern weapons. Ignosi has abandoned the bayonet in his army. Still, as a ramrod is a necessity with an arm using metallic ammunition, on account of an occasional failure to extract, he has availed himself of this necessary appendage, and has made it available as a pike. I take pleasure in stating that this ingenious device is due to an American officer, Colonel Buffington. Its method of operation is shown on the screen.

For carrying small-arm ammunition for single-loaders, Ignosi has adopted the Mills cartridge belt—before you. The cartridges are easily taken out of the loops, as you see. The greater portion of the Kukuanian army is supplied with a rapid-firing single-loader, a most excellent weapon, but for two reasons, Ignosi has determined gradually to adopt a repeating gun, one that shall be as good as the best single-loader, and yet, when occasion demands, be an efficient magazine arm. These reasons are, first, in an engagement, a crisis may come when it is of vital importance to deliver a rapid, continuous fire, a veritable *feu d'enfer*, without taking the piece from the shoulder; and, secondly, because in winter campaigns the cold may so benumb the fingers that the handling of single cartridges becomes awkward. When a man pummels you, you must choose one of two possible alternatives, pummel back or run away. So in battle, and I shall have to revert to this idea in speak-

ing of the Kukuanian target practice, men *will fire* at each other, and with modern breech-loaders, even a few minutes' firing entails enormous expenditure of ammunition. The combatant first out of ammunition is apt to reserve further fighting for "another day." Ignosi, influenced by these considerations, concluded that every soldier going into action must carry in immediate accessible shape not less than 150 cartridges. He accomplished this by radically changing the accustomed method of packing. Instead of the usual small boxes holding the cartridges, he substituted endless muslin bands, furnished with fifty "casings," each of which holds a shell, precisely as the belt does. Immediately preceding an engagement, two of these bands are given to each man, who slings them over his shoulder, as you see. This plan also permits the ready supply of the fighting line, by means of pack mules laden with these bands ready for distribution. Ignosi has adopted a detachable magazine gun, apparently the only form of arm that fulfils the condition of being as good as the best single-loader, for it is a single-loader, and yet is, when required, one of the best of repeaters. For the personal carriage of ammunition, he has adopted the same plan as for the single-loader, a magazine belt and magazine bands, as is shown on the screen.

As regards cavalry, Ignosi acted in accordance with conclusions founded upon the general drift of modern experience, and upon the inevitable necessities of future battle formations. The results of experience induced him to consider cavalry as mounted infantry, and the "trooper's" special equipment differed in no respect when mounted from what it was when afoot.

The horse is furnished as a means of rapid transportation, and everything additional carried was intended for *his* comfort, and not for the rider's. Ignosi recalled the telling effect of even small weights upon the animal's endurance, as shown especially in handicap races, and he insisted that the living vehicle should be laden as lightly as possible, hence the horse carried nothing but what was needed for his health, his sustenance, his security, his management, with a single exception to be presently noted. The neces-

sities of future battle formation, by which Ignosi meant, in a word, greatly extended lines, require that the commanding general should have it in his power to hurl a sufficient force rapidly, unexpectedly, upon some exposed point, and therefore Ignosi provided for heavy *mounted* reserves, that could be promptly entered at the weak spot.

As the ordinary carriage of the rifle and reserve ammunition would prove impracticable in such fierce riding as might on occasion be required, Ignosi has adopted the invention of an American cavalry officer, Captain Hunter, and has attached to the saddle, gun and ammunition pockets, as shown on the screen.

A few words on the Kukuanian target practice are in place here. Ignosi had observed that a mark which fired back had a decidedly quickening effect upon the marksman.

As remarked already, fired-at necessitates firing-back, or shelter. Under such circumstances a man must be kept busy; the immediate work at hand is firing his piece, and he will "peg away" as long as his ammunition lasts, and as rapidly as his arm permits. Under such exciting strain, the average soldier will not tarry to assume correct school positions for aiming and firing, he will "blaze away."

Ignosi had seen men, tolerably taught soldiers, firing under excitement, and he had noticed that as far as aiming was concerned, they had apparently recalled the axiom that two points determine a straight line, had drawn a "bead" from the rear sight to the object, and had contentedly fired. The result is shown on the screen. To make certain that at least the muzzle of the gun is presented at the object, Ignosi attached to his arms a small tube as rear sight. You see that if the piece is at all aimed, it must be pointed correctly.

To simulate the excitement, shifting distances, noise and smoke of actual battle, Ignosi provided for practice movable skeleton targets representing advancing lines, which were pushed by small steel-clad traction engines, whose shrieking and puffing gave life to the movement. In addition, each was furnished with a small Gatling, firing blank cartridges, whose sharp reports, by their aggressive sugges-

tiveness, enhanced the value of the practice. Of course he had exact sharp-shooting competitions at long ranges, one feature of which is worth mentioning. No marker was ever exposed during the practice. A bullet-proof shelter was placed in front and to the side of the target. In this the observer recorded the hits by means of a lens and reflecting prism upon a miniature target, which formed part of a *facsimile* telegraph circuit. The marksman thus saw at once at his side the exact position of his hit.

Ignosi had made artillery a special subject of study; he recognized its predominant importance, for he had seen one of the greatest wars of modern times decided by a superior artillery opposed to a better armed infantry. In his study of this branch of military science, he had been struck by the fact that, with the exception of the recent general introduction of rifled guns, whose superiority had been foretold a century and a half ago, there had been no radical change since the original introduction of cannon as an offensive arm. There had been many changes of detail, necessitated principally by modern improvement in manufacturing processes, but aside from these, in its general aspect, he found the artillery of to-day what it had been in the wars of Frederick and Napoleon. In the equipment of infantry, the great underlying principle of modern warfare had been relentlessly applied, everything that was not absolutely essential had been lopped off, everything had been surrendered for the attainment of the cardinal requisite, mobility. Artillery carriages have been strengthened, guns have been strengthened and are now loaded at the breech, powder has been strengthened, but no emphatic departure from the old system has been obtained.

The complete carriage, the *fourgon*, the wagon that carries the pieces, is to-day in principle what it was when Gustavus Adolphus adopted it. The battery-wagon and forge, one-third of the battery effective, are apparently deemed as necessary to-day, when every campaign condition has changed, as they were during the march to Moscow. He found that the projectiles of to-day, all metal, weather-proof, the powder of to-day so dense as to be almost mois-

ture-repellant, guarded as jealously as when soft wood sabots had to be kept from swelling, as when the loose, absorbent, explosive mixture of the days of yore was cherished as a precious, mysterious, sensitive chemical.

Ignosi had studied the cause of this universal adhesion to traditional requirement. He had endeavored to discover the reason why this most important arm of the service did not progress in sympathy with the *Zeitgeist*, the remorseless pruning spirit of the age. He attributed it to the influence of heredity; he considered it a most remarkable instance of the persistence of ancestral traits. When guns were set up for battle use they were rare and complicated constructions, replacing, not because more simple, but because of greater power, cumbersome mechanical devices, like catapults, whose services required artificers, skilled for the time, and not combatant soldiers. These first cannon occupied fixed positions, as did their prototypes, required equally complicated service, and their attendants were out of the hand-to-hand din of the fight. Ignosi noted that although cannon and arquebuse were almost contemporaneous in development, yet, curiously, their use blindly followed the rule of the bow and the trebuchet. A feudal serf could bend the bow, therefore *he* could use the missile weapon that replaced it. It required science to operate the trebuchet, hence only peculiarly skilled men could be entrusted with its successor, the cannon. For centuries now, by a most marvellous exhibition of transmitted *esprit de corps*, this fictitious distinction has been cherished, and is evidenced to-day in the good-natured tolerance of the artilleryman for his brother-soldier, the "mud-crusher." Of course, the complicated machinery of the middle ages has necessarily disappeared, but for every hampering element "downed," a new one, from Ignosi's point of view, has sprung into vigorous existence. To-day, the development of the capabilities of small-arm fire requires as much science, personal skill, judgment, nerve for its useful application, as does the service of field guns. A plucky fellow can go around the world on a bicycle, carrying his repair material in his pocket, but a four-gun battery, to the reproach of nineteenth-century

military progress, cannot apparently go through a short campaign, without trundling along a village smithy and a country store. Ignosi had looked aghast at the latest tools and stores to be carried in the forge and battery-wagon, every item of which he had been assured was essential. You also have the opportunity—the lists and the note recalls the famous work, "*De omnibus rebus, et quibusnam aliis.*" Yet he had seen such a storehouse on wheels, which had gone through a four years' war, "turned in" with many of the original packages unbroken, explained by the captain's statement that he "had had something else to do than to paint and oil." The old glamour "doth hedge" everything connected with the artillery service, nowhere more pointedly shown than in the mediæval precautions still deemed necessary for the transportation of cartridges and projectiles for cannon, a far simpler problem to-day than the secure carriage of that equally essential element for the usefulness of the command, its supply of sugar. Ignosi was incontestably impressed with the existence of this inherited sentiment by the exhaustive discussions he had heard regarding the proper service of machine guns, the simplest of modern weapons.

An infantry officer is entrusted with fifty or a hundred men, he must teach them to aim, fire and hit, he has numerous and variable personal equations to contend with, he must get his men habituated to the otherwise demoralizing effects of recoil, he must judge distances and correct errors, and his ability to do all this is not impugned. But mount a portion of these same barrels in a rigid frame on wheels, eliminate recoil and personalities, fire them by turning a crank, almost without the possibility of an accident, the successor of the archer must retire, and the descendant of the catapultist take his place. Ignosi determined to break through these trammels of tradition and to bring his artillery in sympathy with the military progress of the age, to make it as mobile as its twin sister, the infantry. He took up the question in detail. (1) He considered the gun-carriage and limber as a wagon, you see a fair exemplar of the usual vehicle on the screen. It is a wagon with a flexible

reach and a rigid pole. Nowhere had he found such another construction. In all his wanderings he had never met a four-wheeler in which these conditions were not exactly reversed. Every wagon he had seen had a rigid reach and a hinged pole. As this was the universal method Ignosi adopted it. He had heard artillery officers complain of the vertical "thrashing" of the pole as destructive to their horses, many ingenious plans had been suggested for the amelioration of this evil, none of which, however, struck at its root. Its cause is easily understood; the limber wheels meet an inequality and are checked; the rigid pole, owing to the pressure of the trail, goes up, the carriage wheels next strike, the trail goes up and the pole down, to the great discomfort of the horse. Hence, in travelling over rough ground, there is a constant scissors-like opening and shutting between carriage and limber, transmitted, of course, in an increased ratio, to the end of the pole.

Yet, as artillery carriages cannot choose their roads, there must be *give* in the construction, customarily obtained in every-day practice by springs.

Furthermore, there must be a simple means of rapidly converting the gun-wagon into a gun-carriage, adequate to sustain the piece in firing. These two essential conditions have for centuries been well met by the established lunette and pintle connection, a strong junction, yet affording an easy, quick and simple means of disjoining limber and carriage. Because it fulfilled these necessary requirements so satisfactorily, this joint has maintained itself to the present, notwithstanding that when it is considered a part of a gun-wagon, it violates the elementary principle of teaming, a virtually stiff connection between front and hind wheels. A rigid pole is a logical sequence of a hinged reach, for in this case, as seen, there is no other provision for keeping the limber body horizontal, nothing else to prevent its continuous "wobbling" up and down. Ignosi formulated the essential qualities which his carriage must possess thus:

A rigid reach; a hinged pole; a universal joint arrangement, replacing the fifth wheel and springs of ordinary vehicles; a sure method for rapidly limbering and unlimbering.

It would consume too much time to describe in detail how he accomplished this—a model is before you, and the construction is shown on the screen. The reach is rigid vertically, movable horizontally, the limber "drawhead" can revolve, the pole is hinged vertically, the three together operate as a universal joint. The pintle is long enough to afford an instantaneous connection should circumstances demand it.

Mobility requires rapid manœuvring. The latest carriage has a turning angle of 55°—Ignosi's a normal turning angle of 90°, an emergency angle of over 100°. To attain this desirable end, Ignosi abolished the pintle hook and substituted a "drawhead," suggested by universal railroad practice. Usually this is checked by chains, yet allowing the spring to act slightly—thus saving many a shock to the horses. In actual combat the chains are unhooked, thereby giving the spring full play.

As the "drawhead" had to be long, it required support. Ignosi upheld it accordingly in the familiar manner, by a truss, as you see. But this interfered with the carriage of the time-honored ammunition chest, so Ignosi gave it up. He adopted an ammunition box, holding three rounds, weighing about fifty pounds, with cover cleverly fastened, as you can see, a device due to Colonel Williston, of the American artillery. Sixteen of these packing-boxes, forty-eight rounds, a greater number than are generally carried, are placed on the limber, and are lashed, if necessary, just as any other load would be. The cartridges are packed in paper bags, perfectly water-proof, hermetically sealed, and easily torn off in action. Ignosi designs that these boxes should also replace the pouches used in carrying the ammunition to the gun.

When the limber becomes a two-wheeler, the simple device shown on the screen, a movable sleeve, locks the pole, and it may gallop off for further supplies, or be used as any cart might. A permanent seat is available for the cannoneers, and capacious receptacles are gained, in which everything necessary for casual repairs is carried, all without important change of dimensions, thus enabling him

to dispense entirely with the ancient forge and battery-wagon. For the rare cases in which a forge may be deemed desirable, Ignosi had adopted the miner's pattern, modified by Colonel Whittemore, and, as here shown, it is readily stowed in the limber boot. The occasions for its use in Kukuanian campaigns will be rare, for "cold shoeing" is an assured success, mild steel has replaced iron, and Ignosi has adopted the Clarke type of wheel, shown in model and on the screen, which can be "knocked down" and assembled without the aid of wheelwright or blacksmith, making the replacing of a broken felloe or spoke a very simple matter.

Ignosi had seen the destructive effects upon the carriage of the severe recoil strains due to modern light guns, long projectiles and heavy charges—this he endeavored to overcome by the device shown in model and projection, a recoil jacket, in which the gun moves, very much as the piston-rod does in the cylinder.

The spring "takes" the initial shock, and thus saves the carriage.

Ignosi placed the machine gun in the same category as the revolver; for offensive purposes he considered it the weapon of the instant. He adopted the latest Gatling with the Accles positive feed, rendering it available for fire at any angle.

As this gun can fire 1,200 rounds per miuute, to make it an integral factor of an advancing line would require an amount of ammunition impracticable to carry with it. Hence Ignosi, while recognizing its great value for *defensive* purposes, each piece virtually representing under these circumstances a full company, did not deem it a feasible element in the engaged line of battle. His reserve, however, was plentifully supplied with Gatlings, each gun fully equipped with 3,600 rounds, *ready for use;* in other words, with thirty-six charged Accles drums, equivalent to three minutes' furious volley firing. He appreciated that in every great battle a moment might come in which a far-seeing commander, by a rapid concentration of aggressive force, without laying bare any portion of his main line, might, by the *coup de main*, overwhelm the enemy. And for this pur-

pose he deemed the machine gun a valuable auxiliary *offensive* weapon.

The clock warns me that I must afford release to your compulsory attention, else I would dwell upon the many other changes made by Ignosi. I would like to describe, for instance, his artillery harness, planned upon that used with steam fire-engines; to tell you how he got rid of the destructive punching and cutting of straps to make them fit; to dwell upon his barracks, his mess outfits, his simple methods of obtaining and accounting for repair material. I would like to go into details regarding the kind and quality of clothing used, to indicate the methods by which he secured unadulterated, unrobbed food for his men. But time forbids; I shall only add that he believed thoroughly that practical *ways* used and approved by the community at large must be good, and he therefore made it a fixed rule to apply them to the army *methods*.

The knowledge he had gained by his own experience, his method of gaining it, by friendly intercourse with keen thinkers, by constant, intelligent observation and examination of what the workers—they who strive hard for necessary profit—do, he grafted upon the military system of his country.

To us, Ignosi is an iconoclast. He has broken the idols of the fathers; he has dissipated the traditions of the ages; he has extirpated the last vestige of feudalism, and he has made the Army of Kukuanaland, of the people, for the people, loved, honored, *respected* by all.

# EXPERIMENTS MADE AT THE NEW YORK NAVY YARD, TO DETERMINE THE RELATIVE ECONOMIC EFFICIENCY, IN PROPORTION OF WEIGHT OF STEAM USED TO WEIGHT OF WATER LIFTED, OF A *RECIPROCATING-PUMP*, A *ROTARY-PUMP*, AND A *STEAM SIPHON-PUMP*, ALL THREE BEING AUXILIARY STEAM-PUMPS FOR VESSELS, AND RAISING WATER TO THE SAME HEIGHT.

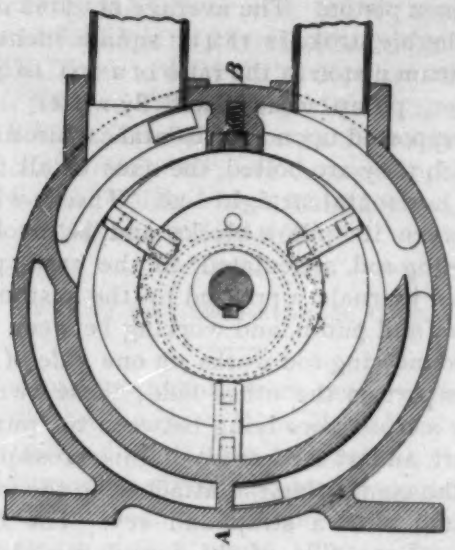
By Chief Engineer Isherwood, U.S.N.

The following experiments were made under the direction of the writer at the New York Navy Yard during the months of March and April, 1867, to ascertain the weight of water lifted through a given height per pound weight of steam expended, by means of a reciprocating-pump, a rotary-pump, and a steam siphon pump. The reciprocating and rotary-pumps were constructed for auxiliary steam pumps on board steamers, to pump water into and out of the boilers, and also from the vessel overboard. The siphon pump was constructed for the latter purpose only. The experiments were conducted, and with the utmost accuracy, by First Assistant Engineer Clark Fisher, U. S. N.

## DESCRIPTION OF THE PUMPS.

The *Reciprocating-Pump* used is known as "The Woodward patent improved safety Steam-Pump and Fire Engine." It is of the No. 4 size. The steam cylinder is 9 inches in diameter and the stroke of its piston is 6 inches. The diameter of the steam piston-rod is $1\frac{3}{4}$ inches, making the average net area of the piston for a double stroke 62·414 square inches. The cylinder is horizontal, and uses the steam without expansion and without condensation. The steam-valve is an ordinary three-ported slide, and is worked by an eccentric on the fly-wheel shaft. The water cylinder or pump is 5 inches in diameter and has a 6-inch stroke of piston, the rod of which is $1\frac{3}{4}$ inches in diameter, being a direct prolongation of the

rod of the steam piston. The average net area of the pump piston for a double stroke is 18·433 square inches, being to that of the steam piston in the ratio of 1·000 to 3·386. The steam cylinder, pump cylinder, and fly-wheel shaft pillow-blocks, are supported upon a horizontal cast-iron foundation-plate, to which they are bolted, the axes of all three being in the same horizontal straight line. The fly-wheel shaft is cranked between its pillow-blocks, and is revolved by an open connecting-rod, articulated to the crank-pin and to two cross-head journals supported by the piston-rod of the steam cylinder and pump, and working between them. One part of the connecting-rod works on one side of the pump, and the other part on the other side; these two parts are connected by a cross-piece lying between the pump and the fly-wheel shaft, and at the centre of this cross-piece is the stub-end of the connecting-rod attached to the crank-pin by brasses, secured with a strap and key. The fly-wheel is overhanging on one side of the foundation-plate, and the eccentric is overhanging on the other side. The pump is provided with a large air-chamber. The suction or receiving-pipe of the pump was 2¾ inches in inside diameter, and 3 feet 7 inches in length. Its cross area was 5·939 square inches, or in the ratio of 1·000 to 3·103 of the pump piston. The discharging-nozzle was of the same inner diameter, namely 2¾ inches, but, for the purpose of the experiment, the discharging-pipe bolted to it was of only 1½ inches inner diameter, giving a cross area of 1·767 square inches; the length of this pipe was 28 feet. From the above figures, the mean velocity of the water in the pump and in the discharging-pipe compares as 1·000 to 10·432. The reason why the diameter of the discharging-pipe was made only 1½ inches instead of 2¾ inches, as intended by the pump maker, was to secure a comparison with the results given by the rotary-pump, the discharge orifice of the latter being 1½ inches in diameter, as intended by its maker. The reduction, however, of the diameter of the discharging-pipe was unfair to the reciprocating-pump, as it produced a greater pressure on its piston than if the intended diameter had been used. Each pump should have been used with its



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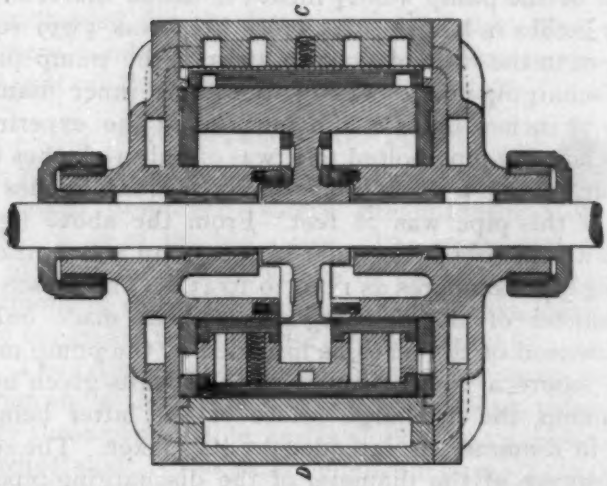

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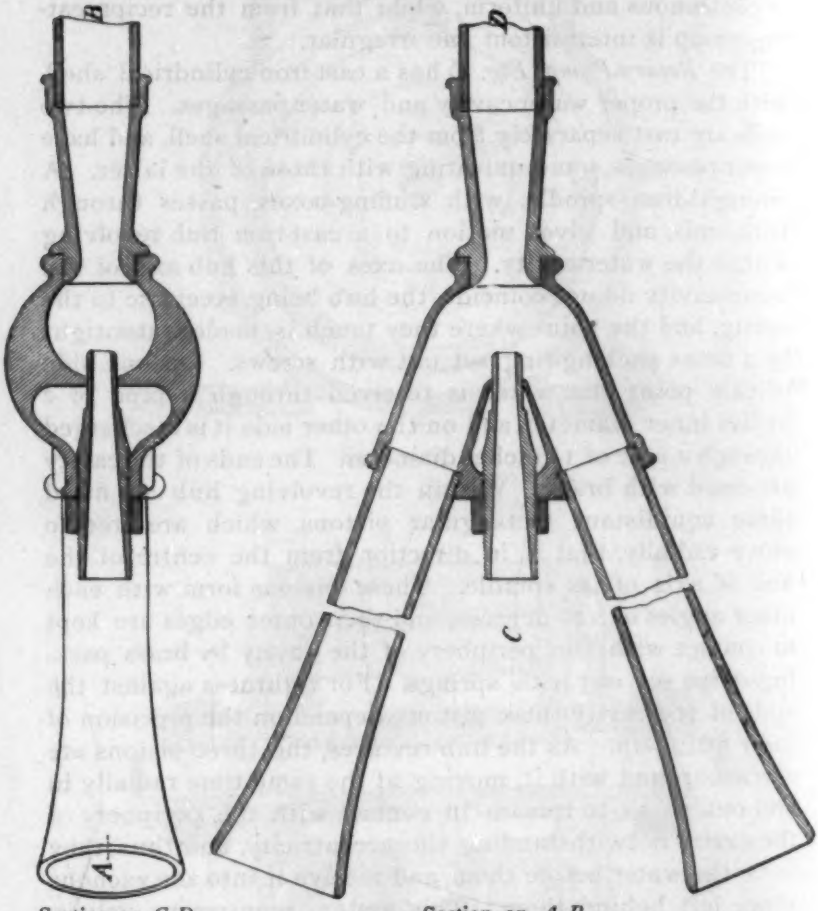
FIG. 1—ROTARY-PUMP.

proper diameter of discharging-pipe, namely 1½ inches for the rotary-pump, and 2¾ inches for the reciprocating-pump. These two types of pump require different diameters of discharging-pipe for the delivery of equal quantities of water in equal times, as the discharge from the rotary-pump is continuous and uniform, while that from the reciprocating-pump is intermittent and irregular.

The *Rotary-Pump* (*Fig. 1*) has a cast-iron cylindrical shell, with the proper water-cavity and water-passages. The two ends are cast separately from the cylindrical shell, and have water-passages communicating with those of the latter. A wrought-iron spindle, with stuffing-boxes, passes through both ends, and gives motion to a cast-iron hub revolving within the water-cavity. The axes of this hub and of the water-cavity do not coincide, the hub being eccentric to the cavity, and the point where they touch is made water-tight by a brass packing-ring set out with screws. On one side of this point the water is received through a pipe of 2 inches inner diameter, and on the other side it is discharged through a pipe of 1½ inches diameter. The ends of the cavity are lined with brass. Within the revolving hub are fitted three equidistant rectangular pistons, which are free to move radially, that is, in direction from the centre of the hub or axis of its spindle. These pistons form with each other angles of 120 degrees, and their outer edges are kept in contact with the periphery of the cavity by brass packing-strips set out with springs. For tightness against the ends of the cavity these pistons depend on the precision of their fitting-up. As the hub revolves, the three pistons are carried around with it, moving at the same time radially in and out, so as to remain in contact with the periphery of the cavity notwithstanding the eccentricity, and thus they force the water before them, and receive it into the vacuous space left behind them. This system requires no valves, and produces a continuous and uniform discharge. It is not a centrifugal-pump, and is as positive in its action as the reciprocating-pump. The diameter of the water-cavity is 7 inches, and its breadth is 5 inches. The pump pistons displace per revolution 109 cubic inches by calculation.

The suction or receiving-pipe was 5 feet 5 inches long; the discharging-pipe was 28 feet long.

The rotary-pump was operated by the same steam cylinder which worked the reciprocating-pump. The latter having




Section on *C D*. Section on *A B*.

FIG. 2.—STEAM SIPHON-PUMP.

been disconnected from its steam cylinder, a 3 inches wide belt was carried from the fly-wheel to a pulley on the spindle of the rotary-pump; the diameters of the fly-wheel and pulley compared as 2·3 to 1·0, consequently the pump made

1·15 revolutions to each single stroke of the steam-cylinder piston.

*The Steam Siphon-Pump* (*Fig. 2*) is simply one of the many applications of Giffard's "Injector." It is composed as follows: Into the lower part of a hollow brass sphere of $5\frac{3}{8}$ inches outside diameter, are screwed obliquely two suction or receiving pipes of 2 inches internal diameter, their axes making an angle with each other of 42 degrees. Between these pipes, and having its axis in the same plane with their axes, is screwed a nozzle for the steam-jet; this nozzle intrudes into the sphere, and its upper end is one-third of an inch above the centre of the sphere; its lower end protrudes below the sphere. The nozzle forms the frustum of a cone, with inner diameter at the base of $1\frac{1}{4}$ inches, and a height of $6\frac{3}{4}$ inches; and to this base, or lower end, is screwed the steam-pipe. Immediately over this nozzle, and having its axis in the same straight line with the axis of the nozzle, there is screwed into the sphere a nozzle for the discharging-pipe; this discharging-pipe nozzle is an inverted frustum of a cone, the lower inner diameter of which is $1\frac{1}{8}$ inches, and the upper inner diameter 2 inches; the height of the inverted frustum is $4\frac{1}{2}$ inches, and into its upper end is screwed the discharging-pipe, 2 inches in internal diameter and 22 feet in length. During the three trials with the siphon-pump, three different nozzles for the steam-jet were used; they all had the same height of $6\frac{3}{4}$ inches, and had the same inner lower diameter of $1\frac{1}{4}$ inches, but the upper inner diameter was respectively $\frac{3}{4}$, $\frac{5}{8}$ and $\frac{9}{16}$ inch, according as the trials were made with steam of 20, 30 and 40 pounds per square inch above the atmosphere in the boiler. The vertical height between the top of the steam-jet nozzle and the bottom of the discharging-pipe nozzle was 3 inches; and the top of the steam-jet nozzle was 54 inches above the lower level of the water lifted. With this system of pump there was, of course, neither valves nor piston, and the water discharge was as continuous and uniform as the steam supply.

The pipe supplying steam from the boiler was 20 feet 6 inches long and $1\frac{1}{2}$ inches in inner diameter. It was thoroughly covered with felt.

All three pumps were furnished and adjusted by their makers for these trials.

### MANNER OF MAKING THE EXPERIMENTS.

The boiler, tanks and pumps employed in the experiments were situated in a closed wooden shed, and well protected from the weather. The steam was supplied by a small boiler placed adjacent to the pumps and used entirely for the purposes of the experiments.

The feed water was pumped into the boiler by a small auxiliary steam pump, which drew it from a wooden tank, lined with sheet lead. This tank was filled, by gravity, from the Navy Yard hydrant, and the feed water was accurately measured in it before being pumped into the boiler. The exhaust steam from the auxiliary steam pump was discharged through a coil of pipe placed in a small cistern, kept filled with cold water from the hydrant for the purpose of condensing it, and was discharged in the form of water, back into the feed-water tank. By this arrangement the weight of water measured in the feed-water tank correctly represented the weight of steam used by the steam cylinder working the reciprocating-pump and the rotary-pump, notwithstanding that the auxiliary steam pump was worked with steam from the same boiler.

Previously to commencing an experiment, all the tanks, the pumps and their connexions, and the boiler, were thoroughly examined for tightness against water leakage; the pumps and boiler were tested under the maximum steam pressure. The boiler and steam-pipes were well covered with felt, but the steam cylinder, working the reciprocating and rotary pumps, had no non-heat-conducting protection.

The supply-tank, from which the water was lifted, was of plate iron, and rested on the floor of the shed. It was filled, by gravity, partly from the Navy Yard hydrant, but chiefly from the receiving-tanks, and the filling was maintained, by the more or less opening of cocks, at such a rate as to keep the surface of the water at a fixed level while the pumps were lifting it. The water was lifted to a vertical height of 17 feet 8 inches, through a discharging-pipe of

1½ inches inner diameter, the length of which for the reciprocating and rotary pumps was 28 feet, and for the steam siphon-pump 22 feet. The discharging-pipe delivered the lifted water for measurement into two receiving-tanks alternately, the one tank being filled while the other was being emptied, and so on. These tanks were of wood, lined with sheet lead, and each contained exactly 160 cubic feet of water, being graduated to precisely that capacity by an overflow-pipe. They were situated, side by side, on an elevated platform, with their bottoms carefully leveled, and were filled over their top edges. At the centre of the bottom of each was a stop-cock, and from it a pipe discharged, by gravity, the contents of the tank either into the supply-tank or into an outside drain.

As the weight of feed water pumped into the boiler was the exact measure of the cost of lifting the water in the different experiments, and as it was essential to the correct making of these experiments that the boiler pr s- sure and position of the throttle-valve should remain constant during each, which could only be effected by the opening or closing of the furnace-door, thereby rendering the weight of coal consumed an inaccurate measure of the cost and of no value in ascertaining the results, the weight of coal consumed has been omitted in the table containing the data of the experiments.

The experiments with the reciprocating and rotary pumps continued seventy-two consecutive hours each, but with the siphon-pump there were made three experiments, each of twenty-four consecutive hours, in order to ascertain the effect of working it with steam of different pressure, namely, of 20, 30 and 40 pounds per square inch above the atmosphere. During each experiment, the conditions were allowed to vary as little as possible. The assistant engineers, four in number, and their attendants, were arranged in watches of six hours each. At the end of every hour there were recorded in a tabular record, by the engineer of the watch, the average temperature, in degrees Fahrenheit during that hour, of the external atmosphere in the shade, of the interior of the shed, of the water in the sup-

ply-tank before it was lifted and of the same in the receiving-tank after it had been lifted, the average height of the barometer and the average steam pressure per gauge in the boiler in pounds per square inch above the atmosphere. In other columns were recorded the number, per counter, of single strokes made during the hour by the steam piston and pump piston of the reciprocating-pump, the number of single strokes made by the steam piston operating the rotary-pump and of revolutions made by the piston of that pump and the number of pounds of feed water pumped by the auxiliary steam pump into the boiler, weighed into the tank used for that purpose. The exact time at which each receiving-tank was emptied was also noted, and, at the end of each experiment, the water in the boiler was left at precisely the same height in the glass water-gauge as at the commencement, and with the same steam pressure upon it.

The data and results of the experiments will be found in the following table, in which, for facility of reference, the quantities are grouped and the lines containing them are numbered, but previous to discussing them an explanation of the quantities will be given.

EXPLANATION OF THE TABLE CONTAINING THE DATA AND RESULTS OF THE EXPERIMENTS MADE WITH THE RECIPROCATING, ROTARY AND SIPHON PUMPS.

Line 1 gives the time at which each experiment commenced.

*Total Quantities.*—Line 2 contains the duration of each experiment in consecutive hours.

Line 3 contains the number of cubic feet of water of the temperature on line 23, lifted through the height of 17 feet 8 inches. This quantity was obtained by measurement of the water in the two receiving-tanks.

Line 4 contains the number of pounds of water lifted through that height. It is obtained, for the experiments with the reciprocating and rotary pumps, by multiplying the quantities on line 3 by the weight in pounds of a cubic foot of water of the temperature on line 23, and, for the experiments with the siphon-pump, by multiplying the

quantity on line 3 by the weight in pounds of a cubic foot of water of the temperature on line 23, and adding thereto the quantity on line 5. The weight of water lifted by the steam siphon-pump is evidently not only the weight lifted from the supply-tank, but also the weight of feed water (line 5) pumped into the boiler. Of course, when the siphon-pump is employed for pumping out the hold of a vessel or similar work, the commercially valuable work done is simply the weight of water lifted, exclusive of the steam condensed in the lifting. The whole of the steam consumed by the siphon-pump is liquefied by the water lifted, and the aggregate weight of the two is delivered into the receiving-tank.

Line 5 contains the number of pounds of feed water pumped by the small auxiliary steam pump into the boiler. This water was weighed hourly into the tank from which the pump drew it, and gives the weight alone of steam consumed in the different experiments for lifting the water from the supply to the receiving tanks, but not for feeding the boiler.

Line 6 contains the number of single strokes made by the piston of the steam cylinder which operated the reciprocating and rotary pumps. The steam cylinder was, of course, double-acting.

Line 7 contains the number of single strokes made by the piston of the reciprocating-pump and of revolutions made by the piston of the rotary-pump. The reciprocating-pump piston was double-acting, and, of course, made stroke for stroke with the steam-cylinder piston. The rotary-pump piston made 1·15 revolutions to each single stroke of the steam-cylinder piston, being geared up by belt and pulleys with diameters in the ratio of 1·0 to 2·3; that is, the pump piston made 2·3 revolutions to each double stroke of the steam-cylinder piston.

*Steam Cylinder.*—Line 8 contains the number of single strokes made per minute by the piston of the steam cylinder which operated the reciprocating and rotary pumps. It is the quotient of the division of the quantity on line 6 by 4,320, the number of minutes the experiments lasted.

Line 9 contains the number of single strokes made per minute by the piston of the reciprocating-pump and of revolutions made per minute by the piston of the rotary-pump. It is the quotient of the division of the quantity on line 7 by 4,320.

Line 10 shows the average pressure during the experiment of the steam in the boiler, in pounds per square inch above the atmosphere.

Line 11 shows the position of the throttle-valve; it remained unaltered during each experiment.

Line 12 shows the average height of the barometer in inches of mercury.

Line 13 shows the estimated mean total pressure on the steam piston in pounds per square inch above zero. This was not obtained by direct measurement, but was estimated in the following manner: The reciprocating-pump was run at the experimental speed of 218¾ single strokes per minute, with the throttle-valve wide open, and the boiler pressure was allowed to regulate itself under these conditions. It was found to be 20 pounds per square inch above the atmosphere. From this there was deduced that the average mean pressure in the steam cylinder for the whole stroke of the piston would be 4·8 pounds per square inch less, or 15·2 pounds per square inch above the atmosphere, making, with the atmospheric pressure (line 12) of 14·8 pounds per square inch, 30·0 pounds.

Line 14 contains the estimated back pressure, which would be the atmospheric pressure of 14·8 pounds per square inch, and something more to expel the steam into it from the cylinder; that something more was assumed to be 0·7 pound per square inch, making the total back pressure resisting the movement of the steam piston 15·5 pounds per square inch above zero.

Line 15 contains the estimated mean gross-effective pressure on the steam piston in pounds per square inch. It is the quantity remaining after subtracting from the quantity on line 13 the quantity on line 14.

Line 16 contains the estimated pressure in pounds per square inch required to work the steam piston and its

attached pump, *per se*, that is to say, without the load, or with the water in the supply-tank shut off.

Line 17 contains the estimated net pressure on the steam piston in pounds per square inch. It is the pressure devoted solely to the lifting of the water from the supply to the receiving-tank.

The object of these estimated steam pressures in the cylinder is to obtain a reasonable approximation of the relation which the total pressure employed in the cylinder bears to the pressure utilized, and consequently an inference as to how economically the total steam pressure was used. Now we find that out of a total pressure of 30 pounds, and for which fuel had been consumed *pro rata*, only 13 pounds were utilized, or 43⅓ per centum. This was due, however, to the unnecessarily large size of the cylinder, and to the fact that the steam was used without condensation, whereby the back pressure was more than the atmospheric pressure. Had the cylinder, while doing the same work, been of the proper size to have worked with steam of 30 pounds per square-inch boiler pressure, and a wide open throttle, the mean total pressure on the piston would have been 40 pounds per square inch, and the back and friction pressures remaining constant (17 pounds per square inch of piston) the net or useful pressure would have risen to 23 pounds per square inch, or 57½ per centum. Under these circumstances the weight of steam expended to do the same work, would have been decreased in the inverse ratio of 43⅓ to 57½, that is would have been in the case of the reciprocating-pump, only 18,082 pounds instead of the 23,993 pounds; the steam being used, as in the experiment, without condensation and without expansion.

Lines 18, 19 and 20, contain the estimated total, gross-effective, and net horse-power developed by the steam cylinder, corresponding respectively to the piston pressures on lines 13, 15 and 17, and to the piston speed due to the number of its single strokes as given on line 8.

It has already been explained how the piston pressures on lines 13, 15 and 17 were obtained in the case of the reciprocating-pump, and how from them resulted the horse

power on lines 18, 19 and 20; but, in the case of the rotary-pump, these pressures and powers were differently obtained. As the steam cylinder was the same with both pumps, and as the velocity of the piston, and the pressures upon it, could not have materially differed, it is obvious that for correct comparison the weight of feed water (line 5) consumed in the two cases would represent accurately the relative *total* horse-power developed by the cylinder, as that power expresses the *entire* dynamic effect produced by the steam, including overcoming the back and friction pressures and the resistance of the water load, etc. Hence, the total horse-power in the case of the rotary-pump (6·715) have been obtained from the total horse-power (6·204) in the case of the reciprocating-pump, by the simple proportion of 23,993 : 6·204 :: 25,970 : 6·715. The total horse-power once known, the total piston pressure (line 13) due to it was easily calculated, and as the back pressure (line 14) and friction pressure (line 16) must have been the same, with the rotary-pump as with the reciprocating-pump, the gross-effective pressure was the remainder after their subtraction from the total pressure. From these pressures the gross-effective and net horse-power developed by the steam piston were calculated as before.

*Temperatures.*—Lines 21 and 22 show the average temperature in degrees Fahrenheit, of the external atmosphere in the shade, and of the interior of the shed, during the experiments.

Lines 23 and 24 show the average temperature in degrees Fahrenheit, of the water raised, both before being raised when in the supply-tank, and after being raised when in the receiving-tank. These temperatures are the same in the cases of the reciprocating and rotary pumps, but differ in that of the siphon-pump, owing to the heat communicated to the water by the steam in its condensation.

*Duty.*—Lines 25 and 26 show the duty performed by the consumption of one pound weight of steam in the cases of the three pumps. By "duty" is meant the net or useful effect produced per unit of cost, which in these cases, on line 25, is the weight of water lifted per pound weight of steam

from the supply-tank to the receiving-tank; including for the rotary-pump the additional weight of feed water pumped into the boiler (line 5), and on line 26 it is the weight of water raised one foot high per pound weight of steam expended.

*Pumps.*—Line 27 shows the number of cubic inches of water actually discharged by the reciprocating-pump per single stroke of its piston, and the number of cubic inches of water actually discharged by the rotary-pump per revolution of its piston. These quantities were obtained by dividing the number of cubic inches of water lifted (obtained from the number of cubic feet on line 3) by the number, respectively, of single strokes made by the reciprocating-pump piston, and of revolutions made by the rotary-pump piston (line 7).

Line 28 shows the number of cubic inches of space displacement of the piston of the reciprocating-pump per single stroke, and the number of cubic inches of space displacement of the piston of the rotary-pump per revolution. Had the pumps completely filled, these capacities would have represented the quantity of water discharged per stroke and per revolution per piston.

Line 29 shows the fraction which the quantity on line 27 is of the quantity on line 28.

## DISCUSSION OF THE RESULTS.

*Siphon-Pump.*—The name of siphon-pump, given to it by its manufacturers, is evidently a misnomer, as there is no siphon action whatever involved. This pump is simply a steam injector and operates on that well-known principle.

In these experiments it was found that with the proportions used, the siphon-pump operated very imperfectly with boiler steam of 20 pounds per square inch above the atmosphere, and that it would not operate at all with a less pressure. Even with the 20 pounds, it required constant watching, stopping about once an hour with heavy concussions similar to those made by blowing steam from a marine boiler through the bottom of the vessel. When thus stopped, a pressure of 25 pounds was required to start

the pump, besides cooling the pump-chambers by forcing cold water down the discharging-pipe, and applying it to the outside of the same. With the 20 pounds pressure the temperature of the supply water could not be carried higher than 60° F.

When the steam pressure was raised in the boiler to 30 pounds per square inch above the atmosphere, the pump worked perfectly, as it also did at the higher pressure of 40 pounds, beyond which the strength of the boiler would not permit the pressure to be carried. With these pressures the highest temperature practicable for the feed water was 68° and 71° F., respectively.

It will be observed there were three experiments made with the siphon-pump, the steam in the boiler being carried respectively at 20, 30 and 40 pounds per square inch above the atmosphere. As the pump worked satisfactorily in the last two cases only, and as the economic result or duty varied in them but a trifle, the mean of those two will be taken for the correct performance. This duty was $\left(\frac{660{\cdot}355 + 661{\cdot}811}{2} =\right)$ 661·083 pounds of water raised one foot high by the expenditure of one pound weight of steam. As this duty includes the weight of steam itself expended in producing it, it represents the entire dynamic effect produced by the steam. The highest temperature practicable for the water in the supply-tank was 70° F., and the temperature of the same when delivered into the receiving-tank was 100°.

As the experiments were for the purpose of determining only the cost in weight of steam consumed in lifting water, the increased temperature given to the water lifted by the siphon-pump does not enter as an element in the comparison of the economic performance of that pump with the economic performances of other pumps. The water lifted was heated about 30° F., by the process of lifting it, and whenever such heating is of utility, its commercial value must be included in estimating the comparative performance of the pump. The exhaust steam, however, from the cylinders driving the reciprocating and rotary pumps, could be used

for the same heating purpose, but would require additional and especially adapted mechanism, thereby increasing the money cost of those pumps.

*Reciprocating-Pump.* The duty with the reciprocating-pump, under the actual conditions of the experiment, was 2397·001 pounds of water raised one foot high by the expenditure of one pound weight of steam, or $\left(\frac{2397{\cdot}001}{661{\cdot}083} =\right)$ 3·626 times greater than that of the siphon-pump, including with the latter the pound of steam itself. It will be recollected, however, in this case, that the steam was used without expansion, and with so high a back pressure that, taken in conjunction with the friction pressure, there was utilized of the total pressure only 43⅜ per centum. Let us suppose, however, that the steam had been used with the same boiler pressure of 30 pounds per square inch above the atmosphere, but with condensation, the back pressure being 3·5 pounds per square inch above zero, and the friction pressure 1·5 pounds per square inch of piston, the steam being cut off at 0·6 of the stroke of the piston from the commencement, then the total indicated horse-power, with a very small steam cylinder, would be obtained for about 40 pounds o steam per hour. The mean total pressure would be abou 38 pounds per square inch above zero, of which (3·5 + 1·5 = 5 pounds would be neutralized by the back and friction pressures, leaving 33 pounds utilized, or 86⅜ per centum. As the total horse-powers developed were 6·204, at 40 pounds of steam per hour each, the consumption of steam would have been 248·16 pounds per hour, or 17,867·52 pounds for the seventy-two hours of the experiment, instead of the 23,993·00 pounds actually consumed; and the duty, instead of being 2397·001 pounds of water raised one foot high per pound weight of steam, would have been 3218·760 pounds, or $\left(\frac{3218{\cdot}760}{661{\cdot}083} =\right)$ 4·869 times greater than that of the siphon-pump, including with the latter the pound of steam itself. Where the economy of fuel is of the slightest importance, it is evident that any competition of the siphon-pump with the reciprocating-pump is hopeless. The former can only be used

advantageously on board a steamer to pump out its bilge after the vessel has just come to anchor, with steam in the boilers; or when the vessel has struck and there is no further use for the main engines. It is very cheap in first cost, cannot become deranged, requires neither attention, adjustment nor repairs, and can be placed wherever there is room for a pipe of a few inches diameter.

A reference to line 29 of the table shows that the water discharge of the reciprocating-pump at each stroke of its piston was 0·864 of the space displacement of that piston per stroke, consequently 0·136 of that space displacement remained unfilled. The speed of the piston of the pump was only 109⅓ feet per minute. The receiving-orifice was large and the receiving-pipe short. The valve, the joints, and the stuffing-box were in complete condition and very tight, having been put in order by the maker and patentee especially for this trial. The 0·136 of the space displacement of the piston stroke unfilled by water must have been filled by air evolved from the water entering the pump under less than the atmospheric pressure, and leaking through the joints and stuffing-box. Part of the water deficiency was also doubtless due to water leakage past the piston and delivering valves, and by regurgitation past the receiving-valves.

*Rotary-Pump.* A single glance at the quantities on lines 25 and 26 of the table is sufficient to show the marked inferiority of the rotary-pump to the reciprocating-pump under the experimental conditions. The duty given on those lines is for the consumption of one pound weight of steam from the boiler, which would have correctly represented the cost of the pumping relatively to that of the reciprocating-pump, had the same pressures been used in the steam cylinder. These pressures however were not the same, the mean total pressure (line 13) being less with the rotary-pump than with the reciprocating-pump, while the back and friction pressures (lines 14 and 16) remained constant; hence, there was a less proportion of the total pressures utilized with the rotary-pump than with the reciprocating-pump. On this account the net horse-

Table containing the data and results of experiments, made in 1867 at the New York Navy Yard, efficiency, in proportion of weight of steam used to weight of water lifted, of a reciprocati siphon-pump, all three raising water to the same elevation of 17 feet 8 inches.

| Number of Line. | | | Reciprocating-Pump. | Rotary-Pump. |
|---|---|---|---|---|
| | | | Steam cylinder, 9 inches diameter and 6 inches stroke of piston, using the steam without expansion and without condensation. Diameter of piston-rod, 1¾-inch. Net area of steam piston, 62·414 square inches. Water cylinder or pump, 5 inches diameter and 6 inches stroke of piston. Diameter of piston-rod, 1¾-inch. Net area of piston, 18·433 square inches. Receiving-pipe of pump, 2¾ inches inner diameter and 3 feet 7 inches long. Discharging-nozzle of pump, 2¾ inches diameter inside, to which is belted a discharging-pipe of 1½-inch inner diameter and 28 feet length. | Steam cylinder 9 inches diameter and 6 inches stroke of piston, using the steam without expansion and without condensation. Diameter of piston-rod, 1¾-inch. Net area of steam piston, 62·414 square inches. The water cavity of the pump is 7 inches in diameter and 5 inches in length. The pump has no valves, and it is geared up by pulleys and belt, to make 2·3 revolutions to each double stroke of the steam cylinder-piston Receiving-pipe of pump 2 inches inner diameter and 5 feet 5 inches length. Discharging-pipe, 1½-inch inner diameter and 22 feet length. |
| 1 | | Date of commencing the experiment, | 12.30 P.M., March 11. | 12.39 P.M., March 4. |
| 2 | TOTAL QUANTITIES. | Duration of the experiment in consecutive hours, | 72· | 72· |
| 3 | | Number of cubic feet of water lifted from the supply-tank through a vertical height of 17 feet 8 inches, | 52,240· | 45,280· |
| 4 | | Number of pounds of water lifted through a vertical height of 17 feet 8 inches; including, for the steam siphon-pump, the pounds of water on line 5, in addition to the pounds of water raised from the supply-tank, | 3,255,353· | 2,822,388· |
| 5 | | Number of pounds of feed-water pumped into the boiler and vaporized to supply the steam for feeding the boiler and for lifting the above quantity of water 17 feet 8 inches high, | 23,993· | 25,970· |
| 6 | | Number of single strokes made by the piston of the steam cylinder, which operated the pumps, lifting the above quantity of water 17 feet 8 inches high, | 944,640· | 1,086,261· |
| 7 | | Number of single strokes made by the piston of the reciprocating-pump, and of revolutions made by the rotary-pump, lifting the above quantity of water 17 feet 8 inches high, | 944,640· | 1,249,200· |
| 8 | STEAM CYLINDER. | Number of single strokes made per minute by the piston of the steam cylinder, which operated the reciprocating and the rotary pumps, | 218·667 | 251·450 |
| 9 | | Number of single strokes made per minute by the piston of the reciprocating-pump, and of revolutions made per minute by the rotary-pump, | 218·667 | 289·167 |
| 10 | | Steam pressure in boiler, in pounds per square inch above the atmosphere, | 30· | 30· |
| 11 | | Throttle valve, | Partly closed. | Partly closed. |
| 12 | | Barometer, in inches of mercury, | 30·17 | 30·45 |
| 13 | | Estimated mean total pressure on the steam piston, in pounds per square inch above zero, | 30·00 | 28·25 |
| 14 | | Estimated mean back pressure against the steam piston, in pounds per square inch above zero, | 15·50 | 15·50 |
| 15 | | Estimated mean gross-effective pressure on the steam piston, in pounds per square inch, | 14·50 | 12·75 |
| 16 | | Estimated pressure on the steam piston, in pounds per square inch, required to work the steam cylinder and its attached pump, *per se*; that is, without load, | 1·50 | 1·50 |
| 17 | | Estimated net pressure on the steam piston, in pounds per square inch, | 13·00 | 11·25 |
| 18 | | Estimated total horse power developed by the steam piston, | 6·204 | 6·715 |
| 19 | | Estimated gross effective horse-power developed by the steam piston, | 2·999 | 3·031 |
| 20 | | Estimated net horse-power developed by the steam piston, | 2·688 | 2·674 |
| 21 | TEMPERATURES. | Temperature of the external atmosphere, in degrees Fahrenheit, | 37·0 | 31·2 |
| 22 | | Temperature of the room in which the apparatus was situated, | 66·7 | 64·2 |
| 23 | | Temperature, in the supply-tanks, of the water lifted 17 feet 8 inches high, | 63·0 | 60·0 |
| 24 | | Temperature, in the receiving-tanks, of the water lifted 17 feet 8 inches high, | 63·0 | 60·0 |
| 25 | DUTY. | Number of pounds of water raised 17 feet 8 inches high, by one pound weight of steam, | 135·679 | 108·679 |
| 26 | | Number of pounds of water raised one foot high by one pound weight of steam, | 2,327·001 | 1,919·992 |
| 27 | PUMPS. | Cubic inches of water discharged per single stroke of the piston of the reciprocating-pump, and per revolution of the rotary pump, | 95·561 | 62·635 |
| 28 | | Space displacement, in cubic inches, of the piston of the reciprocating-pump per single stroke, and of the piston of the rotary-pump per revolution, | 110·580 | 109·000 |
| 29 | | Fraction of the space displacement per single stroke of the piston of the reciprocating-pump, and per revolution of the piston of the rotary-pump, filled with water, | 0·864 | 0·575 |

1 1867 at the New York Navy Yard, to determine the relative economic eight of water lifted, of a reciprocating-pump, a rotary-pump and a steam ion of 17 feet 8 inches.

| | Reciprocating-Pump. | Rotary-Pump. | Steam Siphon-Pump. | | |
|---|---|---|---|---|---|
| | Steam cylinder, 9 inches diameter and 6 inches stroke of piston, using the steam without expansion and without condensation. Diameter of piston-rod, 1¾-inch. Net area of steam piston, 62·414 square inches. Water cylinder or pump, 5 inches diameter and 6 inches stroke of piston. Diameter of piston-rod, 1¾-inch. Net area of piston, 18·433 square inches. Receiving-pipe of pump, 2¾ inches inner diameter and 3 feet 7 inches long. Discharging-nozzle of pump, 2¾ inches diameter inside, to which is belted a discharging-pipe of 1¾-inch inner diameter and 28 feet length. | Steam cylinder 9 inches diameter and 6 inches stroke of piston, using the steam without expansion and without condensation. Diameter of piston-rod, 1¾-inch. Net area of steam piston, 62·414 square inches. The water cavity of the pump is 7 inches in diameter and 5 inches in length. The pump has no valves, and it is geared up by pulleys and belt, to make 2·3 revolutions to each double stroke of the steam cylinder-piston Receiving-pipe of pump 2 inches inner diameter and 5 feet 5 inches length. Discharging-pipe, 1¾-inch inner diameter and 22 feet length. | Two receiving-pipes, each 2 inches internal diameter and 40 inches long. One discharge-pipe, 2 inches internal diameter and 22 feet long. The centre of the pump or mouth of steam-jet is 54 inches above the surface of the water in the supply-tank. Steam-pipe, from boiler to pump, 1⅜-inch internal diameter, 20½ feet long, and felted. | | |
| | | | Steam-jet nozzle, ¾-inch in least inner diameter, used with steam of 20 pounds per square inch pressure above the atmosphere, which was the least pressure with which the pump would work, and even then very imperfectly, stopping about once an hour, with heavy concussions, and requiring the pump chambers to be cooled before again starting. | Steam-jet nozzle ⅝-inch in least inner diameter, used with steam of 30 pounds per square inch pressure above the atmosphere. Pump working perfectly. | Steam-jet nozzle, 9-16-inch in least inner diameter, used with steam of 40 pounds per square inch pressure above the atmosphere. Pump working perfectly. |
| . . . . . | 12.30 P.M., March 11. | 12.39 P.M., March 4. | 10 A.M., April 2. | 10 40 A.M., April 3. | 9 A.M., April 1. |
| . . . . . | 72· | 72· | 24· | 24· | 24· |
| et 8 inches, | 52,240· | 45,280· | 7,840· | 9,760· | 9,440· |
| ng, for the | | | | | |
| ised from | | | | | |
| . . . . . | 3,255,353· | 2,822,388· | 505,752· | 624,596·160 | 603,871· |
| steam for | | | | | |
| . . . . . | 83,993· | 25,970· | 17,070· | 16,710· | 16,120· |
| he pumps, | | | | | |
| . . . . . | 944,640· | 1,086,261· | . . . | . . . | . . . |
| is made by | | | | | |
| . . . . . | 944,640· | 1,249,200· | . . | . . . | . . |
| erated the | | | | | |
| . . . . . | 218·667 | 251·450 | . . . | . . . | . . . |
| of revolu- | | | | | |
| . . . . . | 218·667 | 289·167 | . . . | . . . | . . . |
| . . . . . | 30· | 30· | 20· | 30· | 40· |
| . . . . . | Partly closed. | Partly closed. | Wide open. | Wide open. | Wide open. |
| . . . . . | 30·17 | 30·45 | 30·11 | 30·38 | 29·79 |
| . . . . . | 30·00 | 28·25 | . . . | . . . | . . . |
| ero, . . . | 15·50 | 15·50 | . . . | . . . | . . . |
| . . . . . | 14·50 | 12·75 | . . . | . . . | . . . |
| the steam | | | | | |
| . . . . . | 1·50 | 1·50 | . . . | . . . | . . . |
| . . . . . | 13·00 | 11·25 | . . . | . . . | . . . |
| . . . . . | 6·204 | 6·715 | . . . | . . . | . . . |
| . . . . . | 2·999 | 3·031 | . . . | . . . | . . . |
| . . . . . | 2·688 | 2·674 | . . . | . . . | . . . |
| . . . . . | 37·0 | 31·2 | 46·7 | 49·4 | 44·8 |
| . . . . . | 66·7 | 64·2 | 68·9 | 75·0 | 72·7 |
| . . . . . | 63·0 | 60·0 | 60·0 | 68·0 | 71·0 |
| . . . . . | 63·0 | 60·0 | 100·0 | 98·0 | 100·0 |
| . . . . . | 135·679 | 108·679 | 29·628 | 37·378 | 37·461 |
| . . . . . | 2,337·001 | 1,919·992 | 523·430 | 660·355 | 661·811 |
| pp, and per | | | | | |
| . . . . . | 95·561 | 62·635 | . . . | . . . | . . . |
| stroke, and | | | | | |
| . . . . . | 110·580 | 109·000 | . . . | . . . | . . . |
| pump, and | | | | | |
| . . . . . | 0·864 | 0·575 | . . . | . . . | . . . |

power (line 20) in the two cases will be considered as expressing correctly the relative cost of the pumping. Measured by this standard, the duty of the reciprocating-pump compared with that of the rotary-pump as

$$\frac{3255353\cdot}{2\cdot688} \text{ to } \frac{2822388,}{2\cdot674}$$

or the former was 1·147 times greater than that of the latter.

As the belt communicating the motion of the engine to the rotary-pump caused certainly some friction and had probably some slip, an allowance must be made for these causes of inferiority, because they are not necessary to the pump, which could be worked directly by the engine. When the results of these abnormal causes are eliminated, and when the resistance of the valves of the reciprocating-pump is taken into comparison—the rotary-pump having no valves—the economic performance of the rotary-pump will be found but little less than that of the reciprocating-pump.

The permanent cause of inferiority in the rotary-pump will be found chiefly in the greater water leakage past its pistons, and this leakage is of a nature to increase to a higher proportion as the head of water increases against which it works. Neither can this pump, with its uniformly revolving pistons, fill with water the same proportion of the space displacement of its pistons that the reciprocating-pump can, with its piston coming to a state of rest at the end of its stroke. Hence, we find by inspection of line 29 of the table that, while water to the quantity of 0·864 of the space displacement of its piston was discharged by the reciprocating-pump, the rotary-pump discharged water to the quantity of only 0·575 of the space displacement of its piston.

## HARBOR BAR IMPROVEMENTS.

DISCUSSION BY PROF. L. M. HAUPT.

Since, to ignore the criticisms of Prof. L. d'Auria, as published under this caption in the last number of the JOURNAL, would leave the readers under serious misapprehensions, it would seem to be necessary to submit a few comments in reply.

In the opening paragraph * it is stated in substance that I believe our Government disregards the importance of removing bars from harbor entrances, because it has not as yet seen fit to adopt the plans which I have respectfully submitted looking to that end.

How widely this remarkable assertion differs from the facts will be seen by even a casual reading of my original paper† wherein I have attempted to show that, instead of disregarding the importance of this measure, the United States has endeavored, by all possible means, to effect some substantial improvements, even to the extent of spending large amounts of money and many years in work; but, as I claim, without substantial results. In view of such a finding it became a duty on my part, if possible, to discover the cause and suggest a remedy, and this I have essayed to do. If the Government has not yet seen fit to test these plans it does not follow that others may not, and the writer must have been ignorant of the fact that a foreign government is seriously considering the advisability of their introduction, or he would not have asked the question contained in the second paragraph.

With reference to the measurement of the forces, I have definitely stated that I prefer the measurement as revealed by nature, in the resulting effects produced by their action, rather than theoretical computations based upon a limited number of instrumental observations as to the force and

* Page 224.

† Page 23 and particularly on p. 31.

direction of winds, waves, tides and currents. For, however accurate these latter may be, who can combine them into a formula which shall express the resultant of all of these ever-varying physical conditions? In the computation made in the paper under consideration, the author attempts to discredit my statement that the proposed jetties at Galveston will interfere with the free ingress of the flood, by deducing a formula for the mean velocity of any section, but unfortunately it is not applicable, since it does not include the frictional resistance due to a channel five miles long. It is not to be supposed that for a given difference of level, the surface slope, and hence the velocity, will be the same for a channel five miles long as for one (say) five feet long. Moreover, the Board of Engineers, in their report on the plans for the Galveston jetties, admit that these structures do obstruct the ingress of the flood, for they say, "Such a jettied channel offers more resistance to inflow than does the present entrance; reduces the tidal prism about one-third and hence gives greater difference of level," etc., and again in concluding their report, "The jetties will diminish the freedom of inflow at Galveston."* In short, the attempt to disprove my statement by a formula, merely confirms the conclusion reached by the late talented engineer, General Gillmore, who, after years of experience, said, in speaking of the action of these forces of nature, "The question is full of perplexing difficulties, which elude all the known methods of research by formulæ."†

Again, concerning the demonstration introduced to prove that the "*tidal-wave*" has not sufficient velocity to produce the changes I have mentioned, I have merely to add that there seems to be a further continued misunderstanding of my language, for I have repeatedly disclaimed asserting that it is the tidal *wave*, but on the contrary have given the term *flood component* to the combined forces, causing the observed effects, and have defined this to "include the dynamic action of the breakers racing along the shore as

* *Vide*, pp. 24, 25, vol. cxxxiii, this JOURNAL.

† *Report Chief of Engineers*, 1876, p. 458.

well as the littoral currents generated by the on-shore movements of the flood tide." *

The direction of this flood component or resultant I have attributed to the angle at which the flood-tide approaches the foreshore. By the "racing of the tidal crests," which appears to be the stumbling-block, is meant simply the incessant rolling up of the breakers, generally in an oblique direction, determined largely, as I maintain, by the flood currents, and not the movement of the crest of the tidal-wave, which only occurs at comparatively long intervals.

Finally, Professor d'Auria appears to think the American Philosophical Society were not justified † in awarding the Magellanic Premium for the paper on the "Physical Phenomena of Harbor Entrances," ‡ although it was in its possession for about *nine months* for consideration, and the authorship was *unknown*. The recommendation of the award was made in the earliest possible months permitted by the regulations and it was approved at the same meeting; but this is a part of the subject which I do not feel at liberty to discuss further, since I do not question the competency of the committee, and have abundant reasons, from subsequent examinations and correspondence relative to shore movements, to believe my statements concerning the changes constantly recurring along our alluvial coasts to be fully confirmed by experience, and the Society correct in its conclusions.

As to the congratulations extended to the State of Texas for deliverance from my plans, it may be said that some of the ablest of her civil engineers, as well as prominent citizens living at the very ports under consideration, for periods reaching fifty years, have strongly commended these plans as being the best they have seen and the most likely, in their opinion, to furnish the desired relief.

These personal allusions are believed to be necessary in consequence of the peculiar character of the objections

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* *Proceedings of the American Philosophical Society*, March, 1889.

† *Vide* p. 227, this JOURNAL, for September.

‡ *Vide Proceedings American Philosophical Society*, 1888.

urged in the paper published in the September number of the JOURNAL.

Opinions are not facts and presumptions are not arguments.

## MECHANICAL PROGRESS—THE PAST AND PRESENT CONTRASTED.*

BY GEORGE B. PRICE, M.E., Member of the INSTITUTE.

The purpose of this paper is to indicate something of the wonderful growth of our manufacturing industries in the last twenty years, and to call attention to the wide difference in systems, marking this from previous epochs; especially the introduction of the drafting room, as one of, if not the chief factor in promoting this unparalleled growth of mechanic arts.

To show the invariable superiority of one method over all others for accomplishing a purpose, and to be able to prove by many notable examples the unquestionable value of such method, is to show, at once, the road by which the live men of to-day are winning a deserved success, and a very possible cause of partial failure to those who are yet unacquainted with the very radical change in the situation.

Nothing is truer to this century than the oft-heard phrase, "the world moves on."

Time was when men were satisfied with candle-light.

The ship in which Columbus sailed was doubtless looked upon as a noble craft. Men, for centuries, plowed the earth with wooden plowshares, and the smith at his forge was the nobleman in mechanical skill.

Our century, with its myriad wheels of invention, looks back upon those times as upon a world in its infancy. It was in its infancy. Then men toiled as best they knew how; and with commendable zeal constructed the argosies that have floated humanity to the portals of a new age.

From those portals a new light is shining, with promise of untold wealth. The rapid accretion of knowledge in the scientific world has evolved principles that men knew

* Read by title at the Stated Meeting held Wednesday, September 18, 1889.

nothing of, even a century ago; but which, being recognized and practically applied, are stimulating the great world of industries, abrogating the old and instituting revised methods, to such an extent that men have now grown perfectly familiar with the quotation that "things are not now done as they used to be." How very true! Instead of a small wooden hull, drifting uncertainly upon an almost impassable sea, we have now the advantage of swift and massive "ocean greyhounds," whose grace and perfection tell of a new world of mechanic arts. The smith at his forge, toiling with scarce-requited labor, to express in rude form the conceptions of his individual brain, has given place to our splendid machine shops and great foundries, equipped with "plant" that now makes easily possible what once had been more than a Utopian dream.

The secret of all this change, this wonderful accretion of the wealth of the world, is the genius of invention, controlled by scientific knowledge and wrought out by the subdivision of labor.

This means, when practically applied to our present subject: First, the conception, in one or more minds, of the elementary ideas of an invention. To embody this invention is the work, next, of the mechanical engineer, whose province it is to consider the various principles of construction that enter into the combination; to adjust the different parts to each other and to the whole, having regard to the required solidity, stability, flexibility, simplicity and economy, as well as the most approved or possible methods of casting, welding, finishing and joining those parts, considerations which may not only affect the ultimate practicability of the invention, but, according to the manner in which the subject is treated, will depend largely the grace, symmetry and perfection of the machine.

The position of the mechanical engineer, in this early stage of the work, is as unique as it is important. He is like the doctor who is versed in the principles of medicine, but who, according to his appreciation of the conditions of the case, not less than the ingenuity of his resources, may often build up the patient speedily and lastingly, or only partially and imperfectly.

The physician of known ability is quite likely to be the cheapest in the end; so the timely employment of the engineer is almost certain to mean the best construction of the work proposed, in the shortest time and with the most economy in ultimate cost.

From the hands of the engineer (who should follow up and superintend the subsequent construction) the plans and specifications go into those of the several workmen who are individually instructed, by the drawings, as to the proper way of working up their respective details. There is in this way no clashing or confusion, each man being responsible only for the correct production of his part.

Such seems to be the true explanation of the economic principles of the subdivision of labor.

Men have found out *principles*, and that the most progress is made and wealth more rapidly accumulated when the several stages of any piece of work are each guided and controlled by those who have made *that part* their special study.

We have a very limited idea of the subdivision of labor when we think of it only as of a number of men being divided into groups for the several manual operations in forming, say, a pin. This, indeed, is subdivision of labor; but it should mean more than this. It presupposes antecedent skill and varied ability of a high order.

Before the finished product was possible, an intricate piece of machinery had to be built; which further presupposes not only skilled mechanics, but an inventive genius, and an ability, of somebody, to understand the requirements and correctly portray on paper the many parts, in detail, and as a whole. The designer was quite as necessary as the inventor or the workman.

Let it be remembered, then, that the workshop, though necessary for the practical embodiment of the invention, is yet distinct from the invention. The rule of true progress here is plain. The invention must first be clearly conceived and plainly drawn on paper, clearly and in detail, carefully and studiously designed according to the principles governing the particular construction; in short, it should be wholly

created and visibly expressed in every detail, by one who is master of the subject, before it is put into the hands of a single workman.

How many ambitious, bright, but over-sanguine men have conceived a general notion of some invention, involving mechanical principles of which, most likely, they knew little or nothing, and have thrown away time and hundreds —perhaps thousands—of dollars in blundering along—time and money that might have been saved had they started aright. Most assuredly it can be said, with emphasis, no matter how great or how small the new work proposed, construct it first on paper!

Progressive manufacturers and machinists everywhere are every year recognizing more forcibly the value of this method, and, recognizing it, are growing richer. Look into our best workshops of to-day; the great foundries and machine works that turn out our exact machinery, our fine locomotives, our floating palaces; in all you will find—not "a rule of thumb" and endless experiment, but a well-constituted, thoroughly superintended drawing room. Here the work is first really constructed, on paper, the varied problems carefully thought out, the many parts fitted and proportioned to their several functions; then the various artisans and workers are given their parts, and the whole structure grows uniformly, rapidly, to perfect completion. This is the new way. It has come to stay.

It might be interesting to some to have described the actual working routine of one of our largest and most successful manufacturing establishments—the great locomotive works, whose world-wide reputation has made the American locomotive famous as a competitor on almost every line of railroad in the civilized world. One might naturally conclude that the system preferred by such a firm, after years of fruitful experience—the system which turns out two completed locomotives a day—ought to have superior merit; and if any doubt of this should remain in any one's mind, it should be fully dispersed by the further announcement that the virtues of that same system are being appreciated, and as far as possible imitated by com-

petitive concerns, whose capacity and business are being rapidly enlarged in consequence.

Let us, then, take a swift glance through the said establishment, beginning with the drafting room, which is properly the starting place for our inspection. Here, in a well-lighted, ample apartment, are a number of draftsmen, many of them brought up in the service. These are under the supervision and direction of a superintendent, who originally decides upon the plan of each locomotive to be built, estimating its capabilities and requirements. Instructions and a specification are then given to a draftsman in charge, who carefully constructs on paper elevations and sections necessary to the complete locomotive. The detail drawings are then executed on stiff card-boards, or other materials suited to stand shop-wear, and after passing satisfactory inspection of the examiner of drawings, are given out, carefully numbered and registered, to the respective shops. No work can be done in any of the shops until this is done, thus manifesting the high importance which this successful establishment attaches to correct drawings as the starting point for all construction.

In the shops, the many details are each carefully wrought out, in strict conformity to the drawing, and, as completed, sent to the erecting shop, where, under competent foremen, the various parts are rapidly adjusted, each falling into its proper place, and in an incredibly short time the completed locomotive is breathed into by the breath of its steam-life, and starts upon its career, a giant of force and a monument of engineering skill.

Time was when a complete preliminary drawing was hardly known in a machine shop. Then, men blundered, and blunders are always costly. Time will be soon, when a machine shop without its drawing room, its superintending engineer, will be but a lingering reminder of an experimental age before men had learned the true source of progress and wealth.

Those that still cling, like the smith of old, to the methods of a by-gone age, are falling behind in the race, for while, in a sense, they may be laboriously building up a

small trade, others, taking advantage of the proven better methods for success, will be forging ahead into enviable wealth.

The former has been left behind, not because of inferior ability, in his line, but because he has lost time in trying himself to do what another could have better done, at less expense to him.

There is another and concluding thought that should give hope to every man in the mechanic world.

As his craft grows into closer relationship with the great world of science about and above him, it will certainly lift him to a higher plane. Men are everywhere realizing, as never before, the everlasting truth of fixed principles and universal law governing all things. If a house falls, a bridge gives way, a dam bursts its confines, it is no longer an unaccountable event. Something was deficient. The capacity to detect the cause, the power to avert the evil by a scientific knowledge of the principles of construction is, of all knowledge, the most useful, while its possession, in proportion to its completeness, should raise its possessor to the first ranks among men.

## CHAS. A. TEAL'S PORTABLE HOIST.

[*Report of the Committee on Science and the Arts.*]

[No. 1402.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April, 1889.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred the application of the Teal Hoist Company of Philadelphia, for an examination and report upon the merits of

AN IMPROVED CHAIN HOIST PATENTED BY CHAS. A. TEAL, OF PHILADELPHIA, APRIL 8, 1884, NO. 296,364,

*Report that:* As will be seen by a copy of the patent annexed and by examination of the hoist exhibited:

The hoist consists of a malleable-iron frame suspended

by means of a swivel and hook, much in the usual form of such hoists, but supporting a novel and ingenious form of differential mechanism.

There are several well-known differential hoists in the market, but they all differ widely from Teal's invention.

The nearest approach to it would appear to be the "Weston Chain Hoist," which has two sprocket-wheels cast together or connected side by side upon a shaft, upon which they can turn freely; one of the wheels is larger than the other, having usually one tooth more.

The lift-chain is endless and is so arranged upon these sprocket-wheels that, as they are revolved, the chain runs like a belt, up on one side and down on the other.

The difference between these wheels causes a lengthening or shortening of a bight of the chain, in which the hoisting hook is carried, as the wheels are turned back or forward by a pull upon the lift-chain, and thus any weight attached to the hook is raised or lowered.

In the Teal Hoist the two sprocket-wheels are not side by side, but are upon separate shafts, and they are of the same size; they are also upon opposite sides of a pinion, mounted centrally in the frame of the hoist.

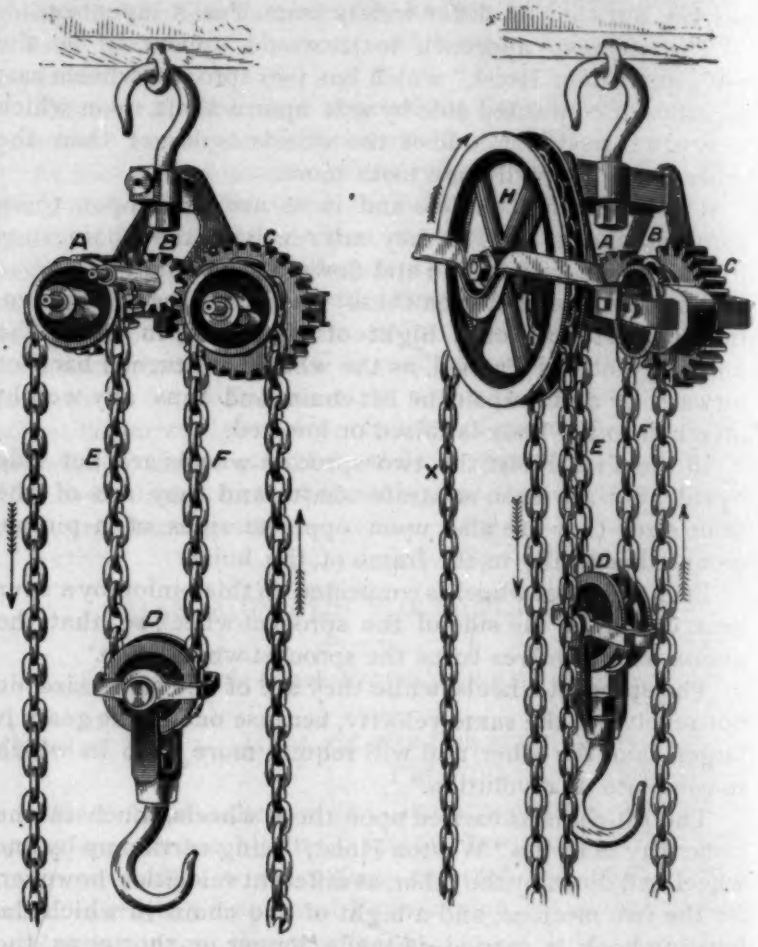
Each sprocket-wheel is connected to this pinion by a spur gear, cast upon the side of the sprocket-wheel, so that the pinion as it revolves turns the sprocket-wheels also.

The sprocket-wheels, while they are of the same size, do not revolve at the same velocity, because one of the gears is larger than the other, and will require more time in which to complete its revolution.

The lift-chain is carried upon these wheels, much in the same way as in the "Weston Hoist," being carried up by one wheel and down by the other, at different velocities, however, for the two motions, and a bight of the chain in which the hoisting hook is carried is made longer or shorter as the central pinion is turned backward or forward.

This pinion has a large grooved wheel upon the outer end of its shaft, and a small endless hand-chain is carried in the groove, so that the wheel and pinion are revolved back or forward by a pull upon the hand-chain. Thus any

load attached to the hoisting hook will be lifted by a pull upon the hand-chain and at a velocity and with an expenditure of force proportioned to the velocity ratio between




the hoisting hook and hand-chain, allowance being made also for the friction of the machine.

This arrangement of the sprocket-wheels, gears and lift chain has also another peculiar action, with consequent advantage.

In the "Weston Hoist" the hoisting hook is lowered by

pulling upon one side of the lift-chain, and raised by pulling upon the other; the only difference being that when the hook is empty the lowering motion may be somewhat quickened, because the chain runs freely and a rapid motion can be given to the chain.

So also in all other hoists known to us, the overhauling or lowering of the hook, is a mere reversing of the hoisting action, and requires the same time as to lift a load; there being in them no provision for applying power to any other part of the hoist, than that by means of the hand-chain, by which the lifting is done.

The Teal hoist, on the contrary, has a slow and powerful motion to lift its load, by means of the hand-chain; and a quick movement for overhauling the chain and lowering the hook for a second lift by a pull directly upon the lift-chain. (This will be seen by examining the machine.)

Supposing the convenient velocity in pulling the two chains to be the same; then in the 1,000-pound hoist examined by us, the hook can be overhauled five times faster by a pull upon one side of the lift-chain, or six seven-tenths times faster by pulling on the other side, than it can be by the hand-chain. This increases the capacity and usefulness of the hoist and is therefore a valuable improvement.

The extent of this improvement can be seen more fully, perhaps, in the table annexed, which gives the velocity ratio and overhauling speed of several well-known hoists, with the ratio of increase in the Teal hoist:

| | Capacity. | Hand-Chain to Hook Velocity Ratio. | Overhaul. | Increase Speed. |
|---|---|---|---|---|
| | *Pounds.* | *Inches.* | *Inches.* | |
| Weston, | 1,000 | 23 to 1 | 23 to 1 | None. |
| Harrington, | 1,000 | 60 to 1 | 60 to 1 | " |
| Box, | 1,000 | 36 to 1 | 36 to 1 | " |
| Wharton, | 1,000 | 36 to 1 | 36 to 1 | " |
| Teal, | 1,000 | 38·5 to 1 | 7·62 to 1 | 5 times. |
| Teal, | . . . | . . . | 5·74 to 1 | 6 7-10 times. |

The use of gears to produce the differential action in place of sprocket-wheels having a different number of teeth, permits the use of a much higher velocity ratio, because the difference between the two sprocket-wheels cannot be

less than one tooth of the wheels or one link in the chain; this would require a very large sprocket-wheel and would be quite impracticable, because of the great increase of weight in the hoist, if the velocity ratio was equal to that readily obtained with gears having small diameter combined with small sprocket-wheels, and therefore having much less weight, as shown in Teal's invention.

This increase of power would, however, soon reach a point where the very slow overhauling speed resulting would more than counterbalance the advantage gained, but for the increased speed due to the pull upon the lift-chain.

The general arrangement and workmanship of the hoist are good. The journals are made self-oiling by having a chamber filled with fibrous packing combined with each journal, and while we think some parts of the malleable iron framing could be with advantage increased in weight and strength, we regard it as upon the whole an excellent hoist, with such novelty and advantage as fully entitle it to receive an award from the committee.

COPY OF REPORT OF TESTS OF PORTABLE CHAIN HOISTS, MADE AT THE "NOVELTIES" EXHIBITION, FRANKLIN INSTITUTE, OCTOBER 20, 1885; ALSO, REPORT OF TESTS OF TEAL'S HOIST UNDER SAME HEADINGS.

| Make. | Capacity. | Shortest Distance Between Hooks. | Movement of Hand-Chain to Movement of Hook. | Weight Lifted. | Weight Required To— | | Per Cent. of Power Wasted in Friction. |
|---|---|---|---|---|---|---|---|
| | | | | | Start Load. | Keep Load Moving. | |
| | *Pounds.* | *Inches.* | | *Pounds.* | *Pounds.* | *Pounds.* | |
| Harrington, . . . . | 2,000 | 18 | 60 | 1005⅛ | 44 | 41 | 59·02 |
| Olsen, . . . . . | 2,000 | 21 | 47⅛ | 1005½ | 66 | 54 | 60·6 |
| Wharton, . . . . . | 2,000 | 20 | 52⅞ | 1005⅝ | 79⅛ | 68⅛ | 72·05 |
| Box, . . . . . | 2,000 | 18½ | 42½ | 1005½ | 87 | 73 | 67·78 |
| Reid, . . . . . | 500 | 18¾ | 38½ | 282 | 35⅛ | 20 | 63·40 |
| Teal, . . . . . | 1,000 | | 38½ | 350 | 21·7 | 20 | 54·6 |
| | | | | | Average 20 tests. | Average. | Main chain did not run freely as it should. |

The results of the tests made by your committee are given above, and in such a manner as to enable a comparison

to be easily made with those obtained by the committee appointed by the Judges of Group No. 13*b*, at the "Novelties" Exhibition of 1885, on Portable Hand Hoists.

In view, then, of the very high efficiency of the hoist, as compared with those tested previously, this hoist showing a considerable increase over the best one then tested, and in view of the increase of capacity and speed in overhauling, we would recommend the award of the JOHN SCOTT LEGACY PREMIUM AND MEDAL to Chas. A. Teal for his invention.

[Signed] MOSES G. WILDER,
*Chairman Sub-Committee.*
FRANCIS LECLERE.

*Adopted, May 1, 1889.*

[Signed] S. LLOYD WIEGAND,
*Chairman of the Committee on Science and the Arts.*

## LECTURES FOR THE SEASON 1889-'90.

The following is the programme of the Lectures to be held during the ensuing winter:

1889.

Monday, November 4.—Daniel Ammen, Rear Admiral, U. S. N., Washington, D. C. *Subject*, "Proposed American Isthmian Canal Routes."

Friday, November 8.—Prof. Lewis M. Haupt, University of Pennsylvania. *Subject*, "Municipal Engineering."

Monday, November 11.—Prof. Ira Remsen, Johns Hopkins University, Baltimore, Md. *Subject*, "Stereo-Chemistry."

Friday, November 15.—Prof. W. LeConte Stevens, Packer Collegiate Institute, Brooklyn, N. Y. *Subject*, "The Development of Aëronautics." (Illustrated.)

Monday, November 18.—Dr. H. Hensoldt, Columbia College, School of Mines, New York. *Subject*, "Natural History in Elementary Schools."

Friday, November 22.—Mr. Chas. Heber Clark, Editor *Textile Record*, Philadelphia. *Subject*, "Work, Waste and Wages."

Monday, November 25.—Prof. C. Herschel Koyl, Washington, D. C. *Subject*, "The Evolution of Railroad Signalling."

Friday, November 29.—Mr. C. John Hexamer, Philadelphia. *Subject*, "A Descriptive and Illustrated Sketch of Canada."

Monday, December 2.—Prof. C. Hanford Henderson, Manual Training School, Philadelphia. *Subject*, "A Lay Sermon on Chemistry."

Friday, December 6.—Mr. Fred. E. Ives, Philadelphia. *Subject*, "The Optical Lantern as a Means of Demonstration." (Illustrated.)

Monday, December 9.—Mr. T. Dunkin Paret, President of the Tanite Company, Stroudsburg, Pa. *Subject*, "Emery Wheels."

Friday, December 13—Mr. Wm. M. Barr, Philadelphia. *Subject*, "The Duty of Pumping Engines."

Monday, December 16.—Mr. Ralph W. Pope, New York, Secretary American Institute of Electrical Engineers. *Subject*, "Electricity: its Past, Present and Future."

Friday, December 20.—Mr. Thomas Pray, M.E., C.E., Boston, Mass. *Subject*, "What Does a Steam Horse-Power Cost?"

1890.

Monday, January 6.—Prof. F. W. Clarke, U. S. Geological Survey, Washington, D. C. *Subject*, "Coal Products."

1890.

Friday, January 10.—Mr. John Carbutt, Philadelphia. *Subject*, "Some New Applications of Photography." (Illustrated.)

Monday, January 13.—Prof. R. L. Chase, Pennsylvania Museum and School of Industrial Art." *Subject*, "A Revolution in Dyeing."

Friday, January 17.—Prof. W. LeConte Stevens. *Subject*, "The Mammoth Cave of Kentucky." (Illustrated.)

Monday, January 20.—Lieut. Bradley A. Fiske, U. S. N. *Subject*, "Electricity in Warfare."

Friday, January 24.—Dr. Edward D. Cope, Philadelphia. *Subject*, "The Influence of Inherited Characters."

Monday, January 27.—Dr. W. Thomson, Philadelphia, Professor Ophthalmia and Surgical Expert Pennsylvania Railroad Company. *Subject*, "Color Blindness."

Friday, January 31.—Mr. C. John Hexamer. *Subject*, "A Descriptive and Illustrated Sketch of Germany."

Friday, February 3—Prof. Louis Duncan, Johns Hopkins University, Baltimore. *Subject*, "Modern Conceptions of Electricity."

Friday, February 7.—Mr. Theodore C. Search, Philadelphia. *Subject*, "Wool—from the Fleece to the Card."

Monday, February 10.—Mr. Eugene Griffin, Thomson-Houston Electric Company, Boston. *Subject*, "Electric Railways."

Friday, February 14.—Mr. Theodore C. Search. *Subject*, "Wool—from the Card to the Fabric."

Monday, February 17.—Mr. Geo. F. Kunz, New York. *Subject*, "Precious Stones." (Introducing copious Lantern Illustrations of the Paris Exposition.)

Friday, February 21.—Mr. Wm. F. Durfee, Superintendent Pennsylvania Diamond Drill Company, Birdsboro, Pa. *Subject*, "Diamond Drilling."

Monday, February 24.—Dr. Charles B. Dudley, Chemist to the Pennsylvania Railroad Company, Altoona, Pa. *Subject*, "Bearing-Metal Alloys."

Friday, February 28.—Mr. Fred. E. Ives. *Subject*, "Street Scenes in Italy caught with the Camera."

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Arrangements are being made for a series of illustrated practical lectures on various handicrafts, designed especially for the instruction of apprentices. Due announcement will be made of this portion of the programme when completed.

By direction of the Committee on Instruction.

WM. H. WAHL, *Chairman.*

*Approved by the Board of Managers, Wednesday, Sept. 11, 1889.*

# PROCEEDINGS

OF THE

# CHEMICAL SECTION,

OF THE

## FRANKLIN INSTITUTE.

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[*Stated Meeting, held at the* INSTITUTE, *Tuesday, September 17, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 17, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: W. H. Bower, Reuben Haines, H. W. Jayne, L. J. Matos, W. W. McFarlane, Thos. N. Newbold, H. Pemberton, Jr., Dr. Wm. H. Wahl, W. D. Weikel.

The resignation of Marshall R. Pugh, to take effect at the end of current year, was presented and accepted. The President read a copy of a proposed amendment to the By-Laws of the INSTITUTE relating to Sections, under which the Sections would be empowered to admit to associate and corresponding membership others than members of the INSTITUTE.

The President exhibited several specimens of the aqueous solution of the allotropic silver, described by Mr. M. Carey Lea.

Dr. Wahl presented for inspection a specimen of aluminium, manufactured at present on the commercial scale by the Pittsburgh Reduction Company. The process employed is that of —— Hall, of Oberlin, O., which consists substantially in dissolving alumina by igneous fusion in a bath of metallic fluorides, and electrolyzing the resulting solution, by which, it is affirmed, the alumina is decomposed while the solvent remains unaffected. Dr. Wahl spoke in general terms of certain technical applications of aluminium, especially to the increasing use of ferro-aluminium by foundrymen to improve inferior irons. He also exhibited several medallions struck from aluminium, made by the Aluminium Company, limited, at the works at Oldbury, near Birmingham, England. They had been presented by Mr. H. Y. Castner, whose process is there in operation.

Adjourned.

H. W. JAYNE, *Secretary pro tem.*

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Following is a list of the members of the CHEMICAL SECTION at the present time:

| | |
|---|---|
| Allen, A. W., | Pencoyd Iron Works, Pencoyd, Pa. |
| Bower, Henry, | Twenty-eighth and Gray's Ferry Road. |

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| Bower, W. H., | Twenty-eighth and Gray's Ferry Road. |
| Browning, G. G. | 44 N. Front St. |
| Bullock, Charles, | 528 Arch St. |
| Bullock, Wm. W., | 528 Arch St. |
| Campbell, J. H., | Kingman, Mojave Co., Ariz. |
| Carter, John E., | Coulter and Knox Sts., Germantown. |
| Chase, Prof. R. L., | 1336 Spring Garden St. |
| Clarkson, Philip S., | Quaker City Dye Works, 110 Oxford St. |
| Cresson, Dr. Chas. M., | 413 Locust St. |
| Day, Prof. W. C , | Swarthmore College. |
| DeBalas, Victor, | 44 N. Front St. |
| Eastwick, J. H., | Wissahickon Station. |
| Eastwick, A. T., | Wissahickon Station. |
| Fisher, R. A., | 2239 St. Alban's Place. |
| Frankel, Lee K., | University of Pennsylvania. |
| Frazer, Dr. Persifor, | Drexel Building, Room 1042. |
| Garrison, F. Lynwood, | Radnor, Pa. |
| Greene, Dr. Wm. H., | 204 N. Thirty-sixth St. |
| Haines, Reuben, | 738 Sansom St. |
| Hall, Prof. L. B., | Haverford College. |
| Hooker, Dr. S. C., | Franklin Sugar Refinery. |
| Hunter, Thos. G., | Fifty-fifth St. and Paschall Ave. |
| Ives, Fred. E., | Crosscup & West, Ninth and Filbert Sts. |
| Jayne, E. C., | 242 Chestnut St. |
| Jayne, H. W., | 931 N. Broad St. |
| Keiser, Dr. E. H., | Bryn Mawr College. |
| Keller, Dr. H. H., | University of Pennsylvania. |
| Koenig, Dr. Geo. A., | University of Pennsylvania. |
| Lea, M. Carey, | 430 Walnut St. |
| Lewin, F. C., | 1011 Spruce St. |
| Lewis, John T., | 242 S. Thirteenth St. |
| Lichenheim, Jacob, | 1614 N. Tenth St. |
| Lüthy, Dr. Otto, | 2336 Fairmount Ave. |
| McFarlane, W. W., | 1600 Park Ave. |
| Matos, L. J., | 3943 Fairmount Ave. |
| Morris, Dr. L. I , | 2505 Oxford St. |
| Morton, Prof. Henry, | Stevens Institute of Technology, Hoboken, N. J. |
| Mucklé, Dr. Alex., | 1323 N. Nineteenth St. |
| Newbold, Thos. N., | 608 S. Forty-second St. |
| Newhall, Geo. M., | 136 S. Fourth St. |
| Oatley, Dr. E. L., | 4003 Chestnut St. |
| Palmer, T. C., | 22 N. Front St. |
| Pemberton, H., | 1947 Locust St. |
| Pemberton, H., Jr., | 1947 Locust St. |
| Petraeus, C. V., | 231 S. Front St. |
| Phillips, Geo. B., | 622 Race St. |

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| Rand, Theo. D., | 17 S. Third St. |
| Rittenhouse, H. N., | 218 N. Twenty-second St. |
| Rowland, W. L., | 4800 Chester Ave. |
| Sadtler, Prof. S. P., | 204 N. Thirty-fourth St. |
| Schaffer, Dr. Chas., | 1309 Arch St. |
| Semper, C. J., | 505 S. Forty-first St. |
| Shaw, H. G., | Thirty-second and Gray's Ferry Road, care Kalion Chemical Co. |
| Smith, Prof. Edgar F., | University of Pennsylvania. |
| Thomas, Prof. N. Wiley, | Girard College. |
| Trimble, Prof. H., | 632 Marshall St. |
| Tuttle, Dr. N. K., | U. S. Mint. |
| Wahl, Dr. Wm. H., | Franklin Institute. |
| Warden, Henry, | 307 Walnut St., 18th St. and Allegheny Ave. |
| Webster, Geo. C., | Media, Pa. |
| Weikel, W. D., | Merchantville, Camden Co., N. J. |
| Whitney, Asa W., | 1815 Vine St. |
| Wiegand, S. Lloyd, | 146 S. Sixth St. |
| Wolf, Dr. T. R., | Newark, Del. |
| Wolff, Lawrence, M.D., | 333 S. Twelfth St. |
| Wyeth, F. H., | 1412 Walnut St. |

## GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Agricultural Experiment Station of the Agricultural and Mechanical College, Alabama. Bulletin No. 6. New Series. From the Station.

American Association for the Advancement of Science. Proceedings of Thirty-seventh Meeting. From the Association.

American Gas Light Association Proceedings. Vol. 8. General Index to Proceedings. Vols. 1 to 8. From the Secretary.

American Institute of Mining Engineers. Eleven Pamphlets, Subject to Revision. From the Institute.

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Hale, Edwin M. The Cat and its Diseases. From the Author.

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Hichborn, Philip. Report on European Dockyards,
From the Navy Department.

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From the Institution.

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New Jersey Agricultural Experiment Station. Bulletin F., 56, 57 and 58. From the Director.

New Mausoleum. A secure Sanitary Sepulchre. From the New Mausoleum Company.

New York, State of. Report of the Commission to Investigate and Report the most Humane and Practical Method of Carrying into Effect the Sentence of Death in Capital Cases. From Elbridge T. Gerry, Commissioner.

Northampton, Mass. Reports of the Board of Water Commissioners for 1884, 1885, 1887 and 1888. From the Board.

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Abridgments of Specifications Relating to Bleaching, Dyeing and Printing Calico and other Fabrics and Yarns. 1877–1883.

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Pennsylvania. Auditor General's Report on Banks. 1888.

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State Librarian's Report. 1887–1888.

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Philadelphia. Second Annual Message of Edwin H. Fitler.
From his Honor the Mayor.

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Quarantine Conference. Proceedings held in Montgomery, Ala.

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## Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, September 18, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, September 18, 1889.

Dr. ISAAC NORRIS, in the Chair.

Present, ninety-four members and thirteen visitors.

Additions to membership since last report, twenty-two.

The report of a special Committee, composed of Professors EDWIN J. HOUSTON and L. D'AURIA and Mr. HUGO BILGRAM, who were appointed to examine a communication submitted for the award of the Boyden